Kinetix Safe-off Feature

Safety Reference Manual

(Bulletin Numbers 2094 and 2099)

ALLEN-BRADLEY • ROCKWELL SOFTWARE

Rockwell Automation

Important User Information

Solid state equipment has operational characteristics differing from those of electromechanical equipment. Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls (publication SGI-1.1 available from your local Rockwell Automation sales office or online at http://literature.rockwellautomation.com) describes some important differences between solid state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

WARNING	Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.
ATTENTION	Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.
SHOCK HAZARD	Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.
BURN HAZARD	Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.

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Preface

Important User Information 2
About This Publication 5
Who Should Use This Manual 5
Conventions Used in This Manual 5
Understanding Terminology 5
Additional Resources 6

Chapter 1

Safety Concept and Troubleshooting

SIL 3 Certification 7
Safety Category 3 Requirements 8
Stop Category Definitions 8
Description of Operation 9
Functional Proof Tests 10
Troubleshooting the Safe-off Function 10
Understanding the Safe-off Condition versus Drive Fault . 11
Safe-off Drive Components 13
PFD and PFH Specifications 14
Definitions of PFD and PFH 14
PFD and PFH Calculations 14
Contact Information Should Device Failure Occur 15

Chapter 2

Safe-off Connector Data

Connector Data 17
Safe-off (SO) Connector Pinouts 18
Understanding Safe-off Connections 20
Safe-off Headers 20
Safe-off Header Configurations 20
Safe-off Interface Cables 23

Chapter 3

Wiring Your Kinetix Safe-off Drive

European Union Directives 25
EMC Directive 25
CE Conformity 26
Low Voltage Directive 26
Understanding the Kinetix Safe-off Feature 26
Safe-off Connection Examples 27
Safe-off Wiring Examples for SIL 3 Applications 30
Safe-off Block Diagram 32
Safe-off Wiring Requirements 33

Appendix A

Specifications

Safe-off Response Time Specifications 35
Safe-off Signal Specifications 36
Safe-off ENABLE Signal Specifications 36
Safe-off FDBK Signal Specifications 36

Appendix B

Kinetix Safe-off Wiring Diagrams

Kinetix Safe-off/Safety Relay Configurations 38
Kinetix Safe-off/GuardLogix Configurations 42
Kinetix Safe-off/GuardPLC Configurations 46

About This Publication

This manual provides detailed installation instructions for wiring and troubleshooting your Kinetix 6000 and Kinetix 7000 safe-off drives. Included are interconnect diagrams with Allen-Bradley safety relays, GuardLogix controllers, and GuardPLC controllers.

Who Should Use This Manual

This manual is intended for engineers or technicians directly involved in the installation and wiring of the Kinetix 6000 and Kinetix 7000 drives, and programmers directly involved in the operation, field maintenance, and integration of the Kinetix 6000 and Kinetix 7000 drives in a safe-off application.

If you do not have a basic understanding of the Kinetix 6000 and Kinetix 7000 drives, contact your local Rockwell Automation sales representative for information on available training courses.

Conventions Used in This Manual

The following conventions are used throughout this manual:

- Bulleted lists such as this one provide information, not procedural steps.
- Numbered lists provide sequential steps or hierarchical information.
- **Bold** type is used for emphasis.

Understanding Terminology

This table defines acronyms used throughout this manual.

Acronym	Full Term	Definition
1oo2	One Out of Two	One Out of Two Safety Architecture. Consists of two channels connected in parallel, such that either channel can process the safety function. Thus, a dangerous failure would have to occur in both channels before a safety function failed on demand.
DC	Diagnostic Coverage	The ratio of the detected failure rate to the total failure rate.
EN	European Norm	The official European standard.
PFD	Probability of Failure on Demand	The average probability of a system to fail to perform its design function on demand.
PFH	Probability of Failure per Hour	The probability of a system to have a dangerous failure occur per hour.
HFT	Hardware Fault Tolerance	Equals N, where N+1 faults could cause the loss of the safety function. A hardware fault tolerance of 1 means that 2 faults are required before safety is lost.
SFF	Safe Failure Fraction	The sum of safe failures plus the sum of dangerous detected failures divided by the sum of all failures.
IGBT	Insulated Gate Bi-polar Transistors	Typical power switch used to control main current.

Additional Resources

These documents contain additional information concerning related Rockwell Automation products.

Resource	Description
Kinetix 6000 Multi-axis Servo Drive User Manual, publication 2094-UM001	Detailed mounting, wiring, setup with RSLogix 5000 software, applying power, and troubleshooting information, with appendices to support firmware upgrades, common bus applications, and Bulletin 2090 resistive brake module (RBM) applications.
Kinetix 7000 High Power Servo Drive User Manual, publication 2099-UM001	Detailed mounting, wiring, setup with RSLogix 5000 software, applying power, and troubleshooting information, with an appendix to support firmware upgrades.
DeviceNet Modules in Logix5000 Control Systems User Manual, publication DNET-UM004	Information on controlling devices on the DeviceNet network.
DeviceNet Safety User Manual, publication 1791DS-UM001	Information on installing and configuring the 1791DS Series modules.
System Design for Control of Electrical Noise Reference Manual, publication GMC-RM001	Information, examples, and techniques designed to minimize system failures caused by electrical noise.
EMC Noise Management DVD, GMC-SP004	
Rockwell Automation Configuration and Selection Tools website, website http://ab.com/e-tools	Online product selection and system configuration tools, including AutoCAD (DXF) drawings.
Rockwell Automation Product Certification, website http://rockwellautomation.com/products/certification	For declarations of conformity (DoC) currently available from Rockwell Automation.
Safety Products Catalog, website http://ab.com/catalogs	Information regarding Allen-Bradley safety products.
Application Considerations for Solid-State Controls, publication SGI-1.1	A description of important differences between solid-state programmable controller products and hard-wired electromechanical devices.
Safety of Machinery - Safety Related Parts of Control Systems, standard EN 954-1	Safety requirements and guidance on the principles for the design of safety related parts of control systems.
Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems, standard EN 61508	Aspects to be considered when electrical/electronic/ programmable electronic systems are used to carry out safety functions.
National Electrical Code, published by the National Fire Protection Association of Boston, MA	An article on wire sizes and types for grounding electrical equipment.
Rockwell Automation Industrial Automation Glossary, publication AG-7.1	A glossary of industrial automation terms and abbreviations.

You can view or download publications at http://literature.rockwellautomation.com. To order paper copies of technical documentation, contact your local Rockwell Automation distributor or sales representative.

Safety Concept and Troubleshooting

This chapter introduces you to the Safety Integrity Level (SIL) concept and how the Kinetix 6000 and Kinetix 7000 safe-off drives meet the requirements for SIL 3 applications. This chapter also provides a troubleshooting table and flowchart for understanding the safe-off mode.

Topic	Page
SIL 3 Certification	7
Description of Operation	9
Functional Proof Tests	10
Safe-off Drive Components	13
PFD and PFH Specifications	14
Contact Information Should Device Failure Occur	15

SIL 3 Certification

The Kinetix 6000 and Kinetix 7000 safe-off drives are **type-approved** and certified for use in safety applications up to and including SIL 3 according to IEC 61508, and applications up to and including safety category (CAT) 3, according to EN 954-1. SIL requirements are based on the standards current at the time of certification.

The TÜV Rheinland group has approved the Kinetix 6000 and Kinetix 7000 drives for use in safety-related applications up to SIL 3, in which the de-energized state is considered to be the safe state. All of the examples related to I/O included in this manual are based on achieving de-energization as the safe state for typical machine safety systems.

IMPORTANT

The system user is responsible for:

- the set-up, SIL rating, and validation of any sensors or actuators connected to the drive system.
- completing a machine-level risk assessment.
- certification of the machine to the desired EN 954 category or IEC 61508 SIL level.
- project management and proof testing.
- programming the application software and the device configurations in accordance with the information in this safety reference manual and the drive product manual.

Safety Category 3 Requirements

Safety-related parts shall be designed such that:

- A single fault in any of these parts does not lead to the loss of the safety function.
- A single fault is detected whenever reasonably practicable.
- Accumulation of undetected faults can lead to the loss of the safety function.

Stop Category Definitions

Stop categories 0 and 1 are defined as follows:

- Stop category 0 is achieved with immediate removal of power to the actuator.
- Stop category 1 is achieved when motion stops before power is removed.

IMPORTANT

In the event of drive or control failure, the most likely stop category is category 0. When designing the machine application, timing and distance should be considered for a coast to stop. For more information regarding stop categories, refer to EN 60204-1.

Description of Operation

The safe-off feature provides a method, with sufficiently low probability of failure on demand, to force the six power-transistor control signals going to the power module to a disabled state. When disabled, or any time power is removed from the safety enable inputs, all six of the power module's output-power transistors are released from the ON state, effectively removing motive power generated by the drive. This results in a condition where the motor is in a coasting condition (stop category 0). Stop category 1 may be achieved with the addition of an external delay element. Disabling the power transistor output does not provide mechanical isolation of the electrical output, which may be required for some applications.

Under normal drive operation, the safe-off relays are energized. If either of the safety enable inputs are de-energized, the gate control circuit is disabled. To meet EN 954-1 safety category 3 and IEC 61508 SIL 3 operation, both safety channels (coil 1 and coil 2) must be used and monitored.

ATTENTION

Permanent magnet motors may, in the event of two simultaneous faults in the IGBT circuit, result in a rotation of up to 180 electrical degrees.

Functional Proof Tests

EN 954 requires that functional proof tests be performed on the equipment used in the system. Proof tests are performed at user-defined intervals, not to exceed one year.

IMPORTANT Users' specific applications determine the time frame for the proof test interval, but it must not exceed one year due to the use of electro-mechanical relays internal to the drive, as required by EN 954.

To proof test the safe-off function, you must interrupt power to the inputs of the safe-off function at pins SO-5 and SO-7 and verify that the drive is in the disabled state. Refer to Safe-off (SO) Connector Pinouts, on page 18 for signal descriptions and pinouts.

Proof Test Truth Table

Safety Function State	Input Channel		Drive Status Indication
	Coil 1 (SO-7)	Coil 2 (SO-5)	
Safe-off function engaged	De-energized	De-energized	Drive output disabled. Drive is in the safe-off state.
Normal operation	Energized	Energized	Drive operates as desired.
Safe-off mismatch	Energized	De-energized	Drive output disabled. Drive indicates safe-off fault.
	De-energized	Energized	

Normal operation of the safe-off function, if monitored and verified, constitutes the proof test. You can verify the safe-off state in RSLogix 5000 software. When either or both coils are de-energized, *axis*.SafeOffModeActiveStatus is set, however, only a safe-off mismatch results in error code E49.

Troubleshooting the Safe-off Function

Error Code	Fault Message **RSLogix** (HIM)	Problem or Symptom	Potential Cause	Possible Resolution
E49	**DriveHardFault** (Safe-off HW Flt)	Safe-off function mismatch. Drive will not allow motion.	• Loose wiring at safe-off (SO) connector. • Cable/header not seated properly in safe-off (SO) connector. • Safe-off circuit missing +24V dc.	• Verify wire terminations, cable/ header connections, and +24V. • Reset error and run proof test. • If error persists, return the drive to Rockwell Automation.

ATTENTION The safe-off fault (E49) is detected upon demand of the safe-off function. After troubleshooting, a proof test must be performed to verify correct operation.

Understanding the Safe-off Condition vs Drive Fault

When both coils de-energize within the 25 ms response time, a fault has not occurred (E49 is not displayed), however, a safe-off condition exists. The safe-off condition occurs through normal drive operation.

A mismatch occurs when one coil is de-energized while the other coil is energized outside of the 25 ms response time. This causes the E49 error code to display and the drive begins a shutdown sequence. Causes for a mismatch include:

- wiring anomalies at the Safe-off (SO) connector, pins SO-5 and SO-7, or the external monitoring relay.
- coil anomalies associated with the Safe-off (SO) connector, pins SO-5 and SO-7.
- sequencing errors in the program.
- EMI interference.

To determine if you have a safe-off fault or condition, you must examine the Axis_Servo_Drive status bit in RSLogix 5000 software.

- If bit status is 0, then no safe-off condition or fault exists.
- If bit status is 1, then a safe-off condition or fault does exist.

RSLogix 5000 Software, v15 Safe-off Status Bit

safe_test2.DriveStatus.11	0		Decimal
safe_test2.DriveStatus.12	0		Decimal
safe_test2.DriveStatus.13	1		Decimal
safe_test2.DriveStatus.14	0		Decimal
safe_test2.DriveStatus.15	0		Decimal

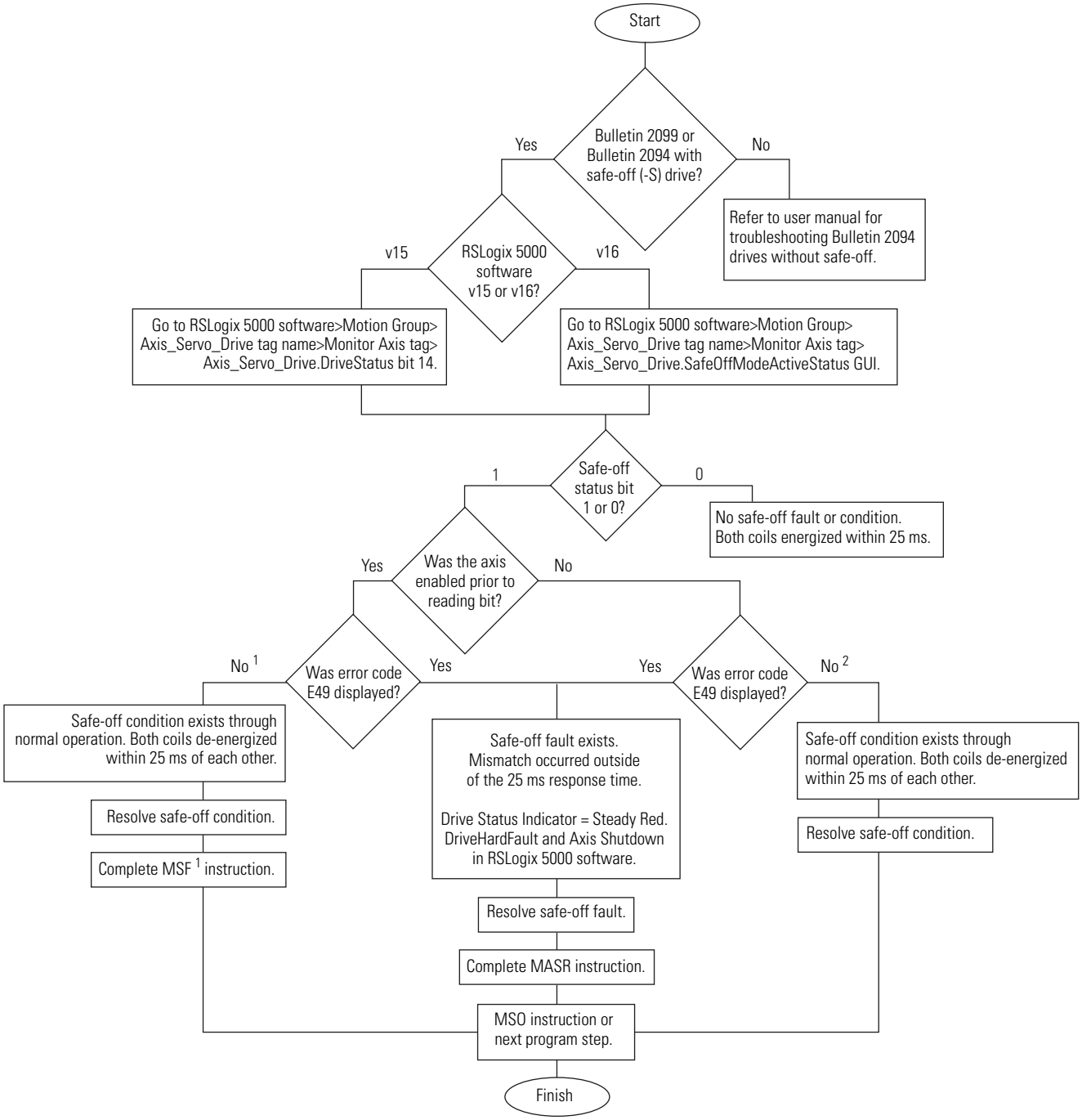
In the RSLogix 5000, version 15 example, the *axis*.DriveStatus.14 bit is set to 0, indicating the drive is not in Safe-off mode. No safe-off condition or fault exists.

RSLogix 5000 Software, v16 Safe-off Status Bit

safe_test2.NegOvertravelInputStatus	0		Decimal
safe_test2.EnableInputStatus	0		Decimal
safe_test2.AccelLimitStatus	0		Decimal
safe_test2.AbsoluteReferenceStatus	0		Decimal
safe_test2.SafeOffModeActiveStatus	0		Decimal

In the RSLogix 5000, version 16 example, the *axis*.SafeOffModeActiveStatus bit is set to 0, indicating the drive is not in Safe-off mode. No safe-off condition or fault exists.

Advanced Safe-off Troubleshooting Flowchart


Start
Bulletin 2099 or Bulletin 2094 with safe-off (-S) drive?
Yes
No
Refer to user manual for troubleshooting Bulletin 2094 drives without safe-off.
RSLogix 5000 software v15 or v16?
v15
v16
Go to RSLogix 5000 software>Motion Group> Axis_Servo_Drive tag name>Monitor Axis tag> Axis_Servo_Drive.DriveStatus bit 14.
Go to RSLogix 5000 software>Motion Group> Axis_Servo_Drive tag name>Monitor Axis tag> Axis_Servo_Drive.SafeOffModeActiveStatus GUI.
Safe-off status bit 1 or 0?
1
0
No safe-off fault or condition. Both coils energized within 25 ms.
Was the axis enabled prior to reading bit?
Yes
No
Was error code E49 displayed?
No 1
Yes
Yes
Was error code E49 displayed?
No 2
Safe-off condition exists through normal operation. Both coils de-energized within 25 ms of each other.
Resolve safe-off condition.
Complete MSF 1 instruction.
Safe-off fault exists. Mismatch occurred outside of the 25 ms response time.
Drive Status Indicator = Steady Red. DriveHardFault and Axis Shutdown in RSLogix 5000 software.
Resolve safe-off fault.
Complete MASR instruction.
Safe-off condition exists through normal operation. Both coils de-energized within 25 ms of each other.
Resolve safe-off condition.
MSO instruction or next program step.
Finish

[1] This is a safe-off condition because the safe-off status bit is set to 1 without an E49 error code. After the condition is fixed, the motion planner must be signaled that the position loop has opened in the condition state with a Motion Servo Off (MSF) instruction before the next Motion Servo On (MSO) instruction can take place. The MSF instruction is necessary because the drive is enabled and running.

[2] This is also a safe-off condition (the safe-off status bit is set to 1 without an E49 error code). The safe-off condition must be resolved, but because the drive is not enabled and running the MSF instruction is not necessary.

Safe-off Drive Components

The SIL 3-certified Kinetix 6000 drive components are listed in this table. For the most current list of components, see http://rockwellautomation.com/products/certification/safety.

Bulletin 2094 SIL 3 Certified Components	IAM Module Cat. No.	AM Module Cat. No.
Kinetix 6000 IAM/AM module with safe-off feature, 230V	2094-AC05-MP5-S	2094-AMP5-S
	2094-AC05-M01-S	2094-AM01-S
	2094-AC09-M02-S	2094-AM02-S
	2094-AC16-M03-S	2094-AM03-S
	2094-AC32-M05-S	2094-AM05-S
Kinetix 6000 IAM/AM module with safe-off feature, 460V	2094-BC01-MP5-S	2094-BMP5-S
	2094-BC01-M01-S	2094-BM01-S
	2094-BC02-M02-S	2094-BM02-S
	2094-BC04-M03-S	2094-BM03-S
	2094-BC07-M05-S	2094-BM05-S

Slots of a SIL 3 system power rail not used by the SIL 3 system may be populated with other axis modules that are certified to the Low Voltage and EMC Directives. Refer to http://rockwellautomation.com/products/certification to find the certificate for the Kinetix 6000 family.

The SIL 3-certified Kinetix 7000 drive components are listed in this table. For the most current list of components, see http://rockwellautomation.com/products/certification/safety.

Bulletin 2099 SIL 3 Certified Components	Cat. No.
Kinetix 7000 High Power Servo Drive	2099-BM06-S
	2099-BM07-S
	2099-BM08-S
	2099-BM09-S
	2099-BM10-S
	2099-BM11-S

For product documentation, refer to Additional Resources on page 6.

PFD and PFH Specifications

This section provides PFD and PFH definitions and calculation examples for the Kinetix 6000 and Kinetix 7000 safe-off drives.

Definitions of PFD and PFH

Kinetix 6000 and Kinetix 7000 safe-off drives operate in either a Low Demand mode or in a High Demand/Continuous mode.

- In Low Demand mode operation, the frequency of demands for operation made on a safety-related system is no greater than one per year or no greater than twice the proof-test frequency.
- In High Demand or Continuous mode operation, the frequency of demands for operation made on a safety-related system is greater than once per year or greater than twice the proof-check frequency.

The SIL value for a low-demand safety-related system is directly related to order-of-magnitude ranges of its average probability of failure to satisfactorily perform its safety function on demand or, simply, average probability of failure on demand (PFD). The SIL value for a high demand/continuous mode safety-related system is directly related to the probability of a dangerous failure occurring per hour (PFH).

PFD and PFH Calculations

The PFD and PFH calculations in the tables below are based on the equations from Part 6 of IEC 61508 with the following assumptions:

- The architecture is 1oo2.
- A detectable error in either channel will be detected on the next demand of the safe-off function.
- The functional proof test interval (T1) is 1 year.
- The hardware fault tolerance (HFT) equals 1.
- The safe failure fraction (SFF) is 89%.
- The fraction of undetected common cause failures (β) is 1%.

PFD and PFH Calculation Examples

Drive Component	Functional Verification Test Interval	PFD(t)	PFH(t)
Kinetix 6000 drives (2094-AC*xx*-M*xx*-S, 2094-BC*xx*-M*xx*-S, and 2094-AM*xx*-S, and 2094-BM*xx*-S)	1 year	1.70E-06	3.88E-10
Kinetix 7000 drives (2099-BM*xx*-S)	15 year	2.73E-05	4.31E-10

IMPORTANT When the machine design uses more than one drive in the safety string where either axis independently or concurrently present a hazardous condition, the values for PFD and PFH must be multiplied by the number of axes to determine the value at the machine level. For example, if a machine load station has a horizontal and a vertical axis and if either axis remaining in motion can present a hazard, the values for PFD and PFH must be multiplied by two.

Contact Information Should Device Failure Occur

If you experience a failure with any SIL 3-certified device, contact your local Rockwell Automation distributor. With this contact, you can:

- return the device to Rockwell Automation so the failure is appropriately logged for the catalog number affected and a record is made of the failure.
- request a failure analysis (if necessary) to determine the probable cause of the failure.

Safe-off Connector Data

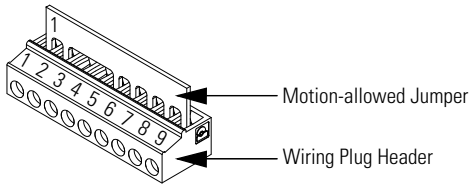
This chapter provides safe-off (SO) connector, header, and interface cable information for the Kinetix 6000 and Kinetix 7000 safe-off drives.

Topic	Page
Connector Data	17
Understanding Safe-off Connections	20
Safe-off Interface Cables	23

Connector Data

Each Kinetix 6000 and Kinetix 7000 safe-off drive ships with the (9-pin) wiring plug header and motion-allowed jumper. With this wiring header/jumper combination installed in the safe-off (SO) connector (default configuration), the safe-off feature is not used.

Wiring Plug Header with Motion-allowed Jumper



Replacement header with jumper is also included in connector sets for the Kinetix 6000 and Kinetix 7000 safe-off drives.

Replacement Connector Sets

Module	Cat. No.	Description	Cat. No.
Kinetix 6000 IAM and AM Module	2094-AC05-M*xx*-S, 2094-AC09-M02-S, 2094-AMP5-S, 2094-AM01-S, 2094-AM02-S	Includes motor power (MP), motor/resistive brake (BC), and safe-off (SO) replacement connectors for the IAM (inverter) and AM.	2094-XNINV-1
	2094-AC16-M03-S, 2094-AC32-M05-S, 2094-AM03-S, 2094-AM05-S, 2094-BC04-M03-S, 2094-BM03-S		2094-ANINV-2
	2094-BC01-M*xx*-S, 2094-BC02-M02-S, 2094-BMP5-S, 2094-BM01-S, 2094-BM02-S		2094-XNINV-1
	2094-BC07-M05-S, 2094-BM05-S		2094-BNINV-2
Kinetix 7000 High Power Drive	2099-BM*xx*-S	Includes safe-off (SO), general purpose I/O (GPIO), general purpose relay (GPR), and control power (CP) replacement connectors for Kinetix 7000 drives.	2099-K7KCK-1

Safe-off (SO) Connector Pinouts

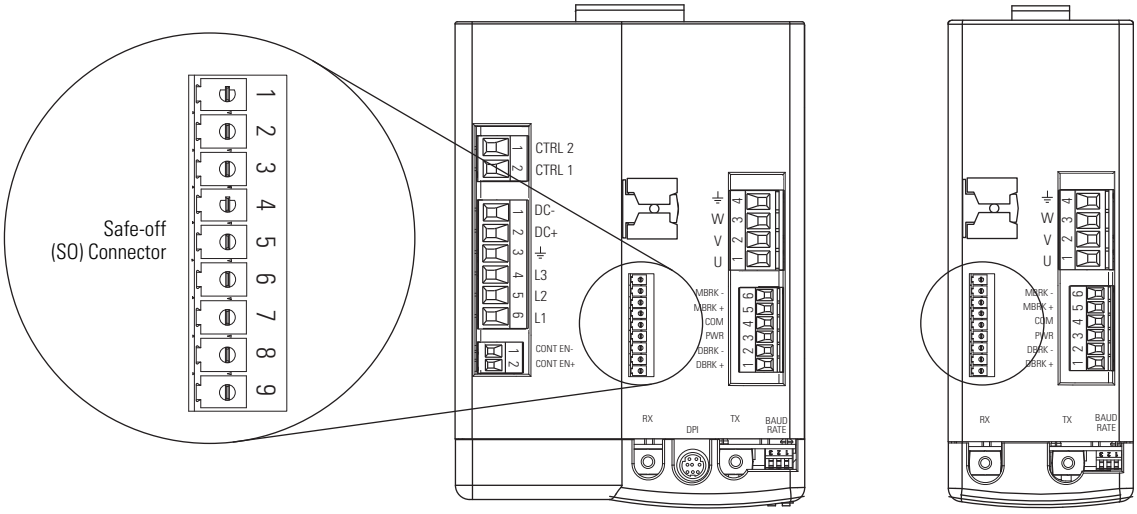
Headers extend the safe-off (SO) connector signals for use in wiring single and multiple safe-off drive configurations, or to defeat (not use) the safe-off function.

9-pin Safe-off (SO) Connector

Safe-off (SO) Connector Pin	Also Applies to These SO Connector Headers	Description	Signal
1	• Wiring plug header used in single-drive applications • First-drive wiring header (2090-XNSM-W) used in multiple-drive applications	One side of the normally-closed monitoring contact of relay 2	FDBK2+
2		Other side of the normally-closed monitoring contact of relay 2	FDBK2-
3		One side of the normally-closed monitoring contact of relay 1	FDBK1+
4		Other side of the normally-closed monitoring contact of relay 1	FDBK1-
5		Coil of safety-relay 2	SAFETY ENABLE2+
6		Return for safety-relay coil power (both relays)	SAFETY ENABLE-
7		Coil of safety relay 1	SAFETY ENABLE1+
8	• Wiring plug header • Motion-allowed jumper	Output power for continuous enable of the safety function, 500 mA max	24V+
9		Output power return used for continuous enable of safety function	24V_COM

IMPORTANT Pins SO-8 (internal 24V+ supply) and SO-9 (24V_COM) are used only by the motion-allowed jumper to defeat the safe-off function. When the safe-off function is in operation, the 24V supply must come from an external source.

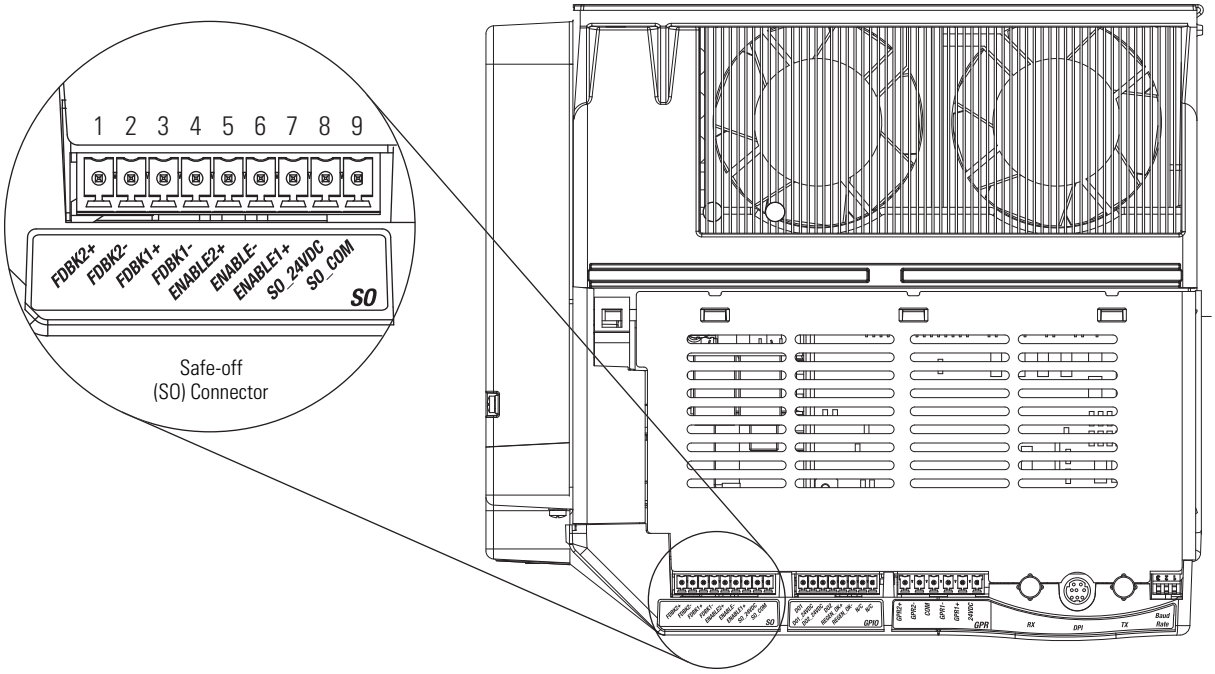
9-pin Safe-off (SO) Connector - Kinetix 6000 Drive



Integrated Axis Module (IAM), Top View
(2094-BC01-MP5-S is shown)

Axis Module (AM), Top View
(2094-BMP5-S is shown)

9-pin Safe-off (SO) Connector - Kinetix 7000 Drive



Kinetix 7000 Drive Module, Top View
(2099-BM06-S is shown)

Understanding Safe-off Connections

The safe-off function can be implemented in a single-drive or extended in up to eight drives in a multiple safety-drive configuration. The connector can also be jumpered to effectively remove the safe-off function.

Safe-off Headers

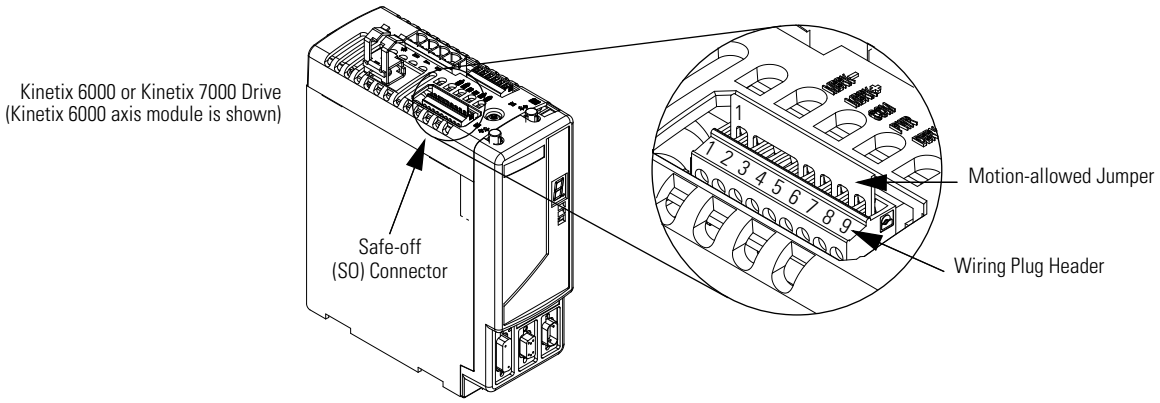
An assortment of headers, when wired and plugged into the safe-off (SO) connector, make implementation possible, as described in this table.

Description	Cat. No.
Safe-off wiring header for the first drive in multiple safety drive configurations (optional).	2090-XNSM-W
Safe-off middle header for drive-to-drive connections in multiple safety drive configurations with three or more drives (optional).	2090-XNSM-M
Safe-off terminating header for the last drive in multiple safety drive configurations (optional).	2090-XNSM-T

Safe-off Header Configurations

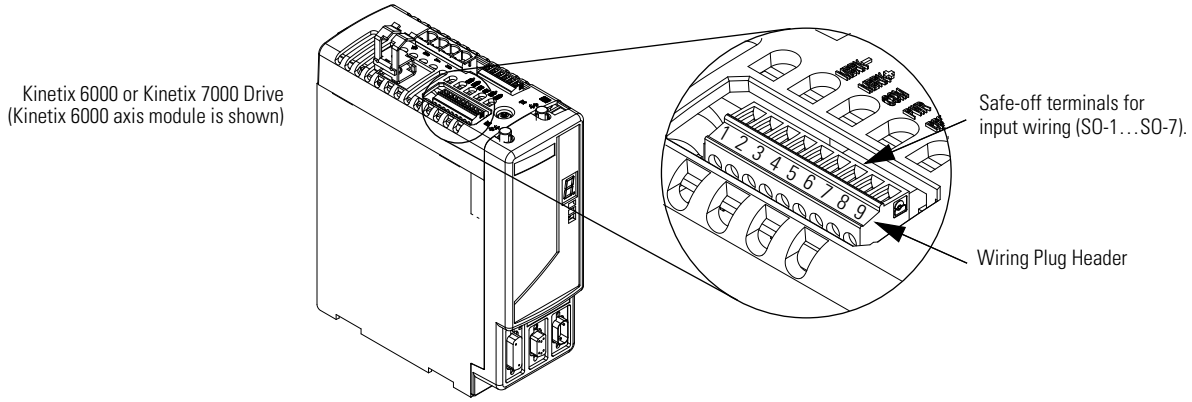
In this example, the Kinetix 6000 axis module is shown with the motion-allowed jumper installed in the wiring plug header. This header/jumper combination (default configuration) ships with each Kinetix 6000 and Kinetix 7000 drive and enables drive operation without external safety-circuit connections.

Motion-allowed Jumper



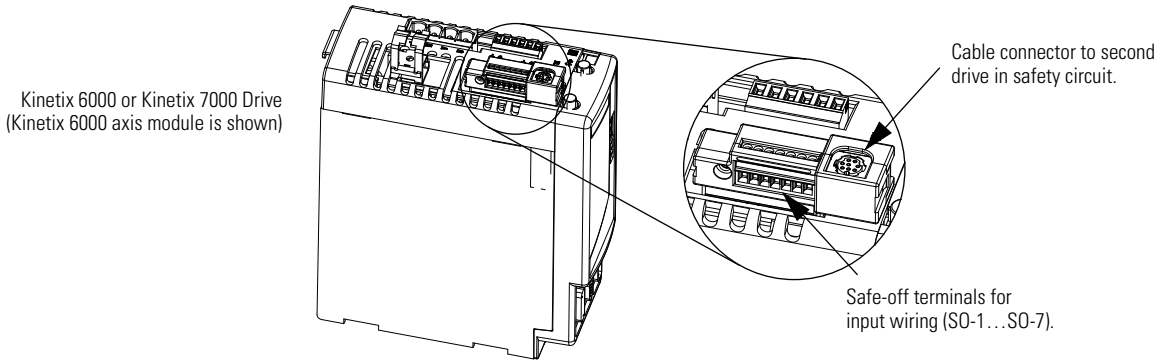
In this example, the Kinetix 6000 axis module is shown with a wiring plug header. The motion-allowed jumper has been removed. Use the wiring plug header alone for wiring Kinetix 6000 single drive safe-off applications.

Single Drive Wiring Header


Kinetix 6000 or Kinetix 7000 Drive
(Kinetix 6000 axis module is shown)
Safe-off terminals for
input wiring (SO-1…SO-7).
Wiring Plug Header

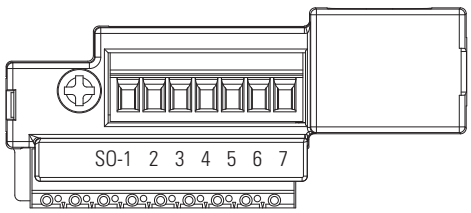
In this example, the Kinetix 6000 axis module is shown with a first-drive wiring header (catalog number 2090-XNSM-W). Kinetix 6000 and Kinetix 7000 first-drive modules use this header in multiple safe-off drive configurations for wiring to a safety control circuit and extending the safe-off circuitry to another drive.

First-drive Wiring Header (2090-XNSM-W)


Kinetix 6000 or Kinetix 7000 Drive
(Kinetix 6000 axis module is shown)
Cable connector to second
drive in safety circuit.
Safe-off terminals for
input wiring (SO-1…SO-7).

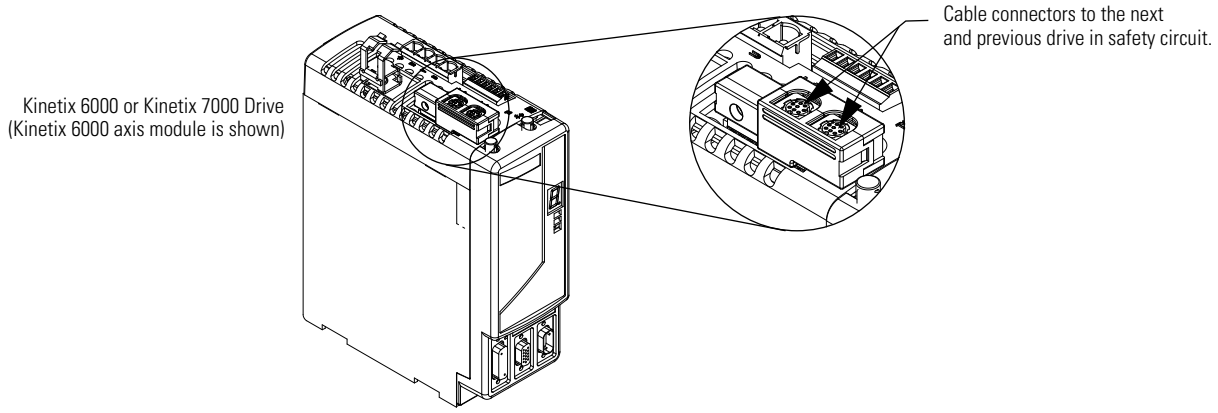
IMPORTANT Do not use the first-drive (2090-XNSM-W) wiring header in single-drive applications.

First-drive Wiring Header Pin Assignment



In this example, the Kinetix 6000 axis module is shown with a drive-to-drive middle header (catalog number 2090-XNSM-M). Kinetix 6000 and Kinetix 7000 drive modules, in safe-off drive configurations of three or more, use this header for making the safe-off connections between drives.

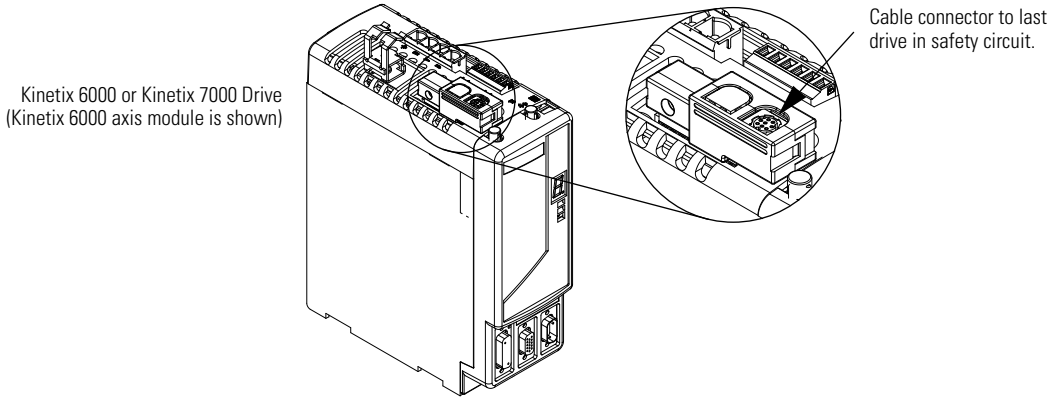
Middle Drive Header (2090-XNSM-M)


Kinetix 6000 or Kinetix 7000 Drive
(Kinetix 6000 axis module is shown)
Cable connectors to the next
and previous drive in safety circuit.

IMPORTANT Next and previous drive cable connection to the middle header (catalog number 2090-XNSM-M) is arbitrary. Input and output is not specified.

In this example, the Kinetix 6000 axis module is shown with a last-drive terminating header (catalog number 2090-XNSM-T). Kinetix 6000 and Kinetix 7000 drive modules use this header in multiple safe-off drive configurations for making safe-off connections to the last drive.

Last Drive Header (2090-XNSM-T)



Safe-off Interface Cables

Safe-off interface cables are required for making connections with 2090-XNSM-W, 2090-XNSM-M, and 2090-XNSM-T safe-off headers.

Safe-off Interface Cables

Description	Cat. No.
Drive-to-drive safety cable, 200 mm (7.9 in.), for connecting single-wide Kinetix 6000 axis modules.	1202-C02
Drive-to-drive safety cable, 350 mm (13.8 in.), for connecting double-wide Kinetix 6000 axis modules.	1202-C03
Drive-to-drive safety cable, 1050 mm (41.3 in.), for connections: • between Kinetix 6000 power rail and Kinetix 7000 drive. • between two Kinetix 6000 power rails. • between two Kinetix 7000 drives.	1202-C10

IMPORTANT Due to the current capacity limitation of the safe-off interface cable connectors, multiple safe-off drive configurations must not exceed eight Kinetix 6000 or Kinetix 7000 drive modules.

Wiring Your Kinetix Safe-off Drive

This chapter provides guidelines for wiring your Kinetix 6000 and Kinetix 7000 safe-off drive connections.

Topic	Page
European Union Directives	25
Understanding the Kinetix Safe-off Feature	26
Safe-off Wiring Requirements	33

European Union Directives

If this product is installed within the European Union or EEC regions and has the CE mark, the following regulations will apply.

For more information on the concept of electrical noise reduction, refer to System Design for Control of Electrical Noise Reference Manual, publication GMC-RM001.

EMC Directive

This unit will be tested to meet Council Directive 2004/108/EC Electromagnetic Compatibility (EMC) using the following standards, in whole or in part:

- EN 61800-3 - Adjustable Speed Electrical Power Drive Systems, Part 3 - EMC Product Standard including specific test methods
- EN 61000-6-4 EMC - Emission Standard, Part 2 - Industrial Environment
- EN 61000-6-2 EMC - Immunity Standard, Part 2 - Industrial Environment

The product described in this manual is intended for use in an industrial environment.

CE Conformity

Conformity with the Low Voltage Directive and Electromagnetic Compatibility (EMC) Directive is demonstrated using harmonized European Norm (EN) standards published in the Official Journal of the European Communities. Kinetix safe-off drives comply with the EN standards when installed according to the applicable user documentation (refer to Additional Resources on page 6).

CE Declarations of Conformity are available online at: http://rockwellautomation.com/products/certification/ce.

Low Voltage Directive

These units are tested to meet Council Directive 2006/95/EC Low Voltage Directive. The EN 60204-1 Safety of Machinery-Electrical Equipment of Machines, Part 1-Specification for General Requirements standard applies in whole or in part. Additionally, the standard EN 50178 Electronic Equipment for use in Power Installations will apply in whole or in part.

Understanding the Kinetix Safe-off Feature

The Kinetix safe-off drives, when used with suitable safety components, provides protection according to EN 954-1 Safety Category 3 and IEC 61508 SIL 3 for safe-off and protection against restart. The safe-off option is just one safety control system. All components in the system must be chosen and applied correctly to achieve the desired level of operator safeguarding.

The Kinetix safe-off drives are designed to safely remove power from the gate firing circuits of the drive's output power devices (IGBTs). This prevents them from switching in the pattern necessary to generate ac power to the motor.

You can use the Kinetix safe-off drives in combination with other safety devices to meet the stop and protection-against-restart requirements of EN 954-1.

ATTENTION

This option is suitable for performing mechanical work on the drive system or affected area of a machine only. It does not provide electrical safety.

SHOCK HAZARD

To avoid an electric shock hazard, verify that the voltage on the bus capacitors has discharged before performing any work on the drive. Be sure the dc bus voltage across the +DC and -DC terminals or test points is zero volts.

Refer to Additional Resources on page 6 for the appropriate drive manual with the terminal locations.

SHOCK HAZARD

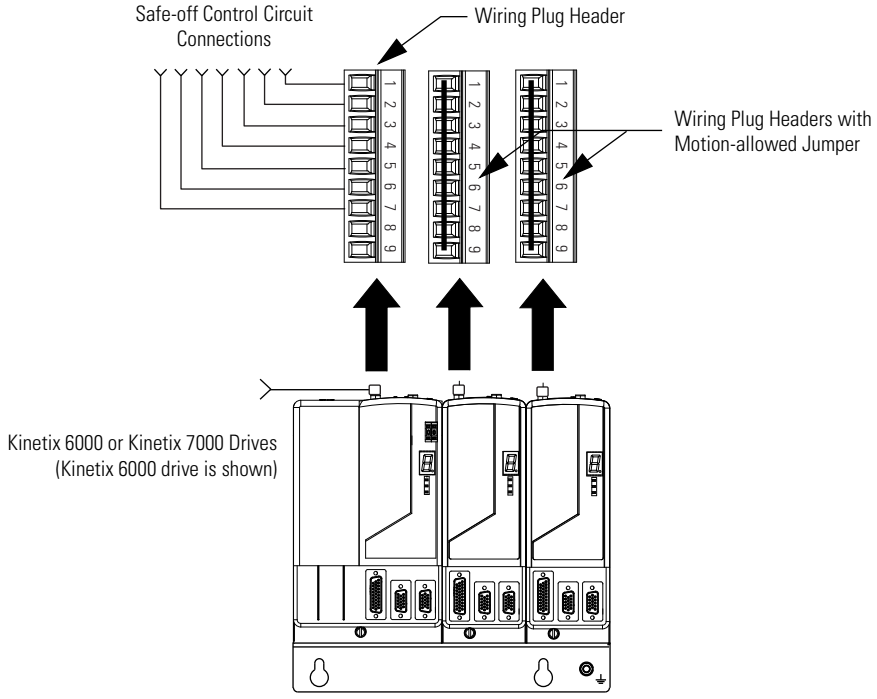
In safe-off mode, hazardous voltages may still be present at the motor. To avoid an electric shock hazard, disconnect power to the motor and verify that the voltage is zero before performing any work on the motor.

Safe-off Connection Examples

Typical safe-off connections for the Kinetix 6000 and Kinetix 7000 drives are shown in the figures below.

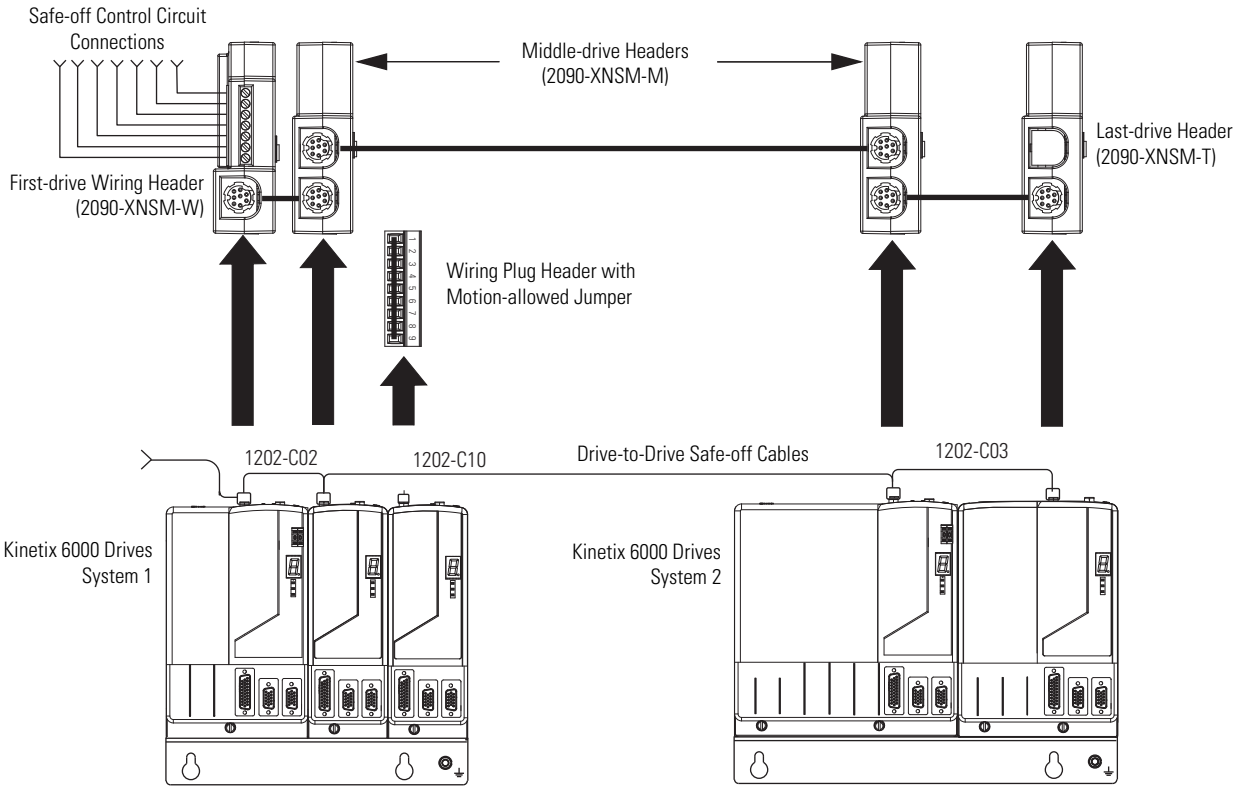
In this example, a single Kinetix 6000 safe-off drive is shown using the wiring plug header. The second and third drives do not use the safe-off feature, so the motion-allowed jumpers remain installed.

Typical Single Drive Safe-off Configuration


Safe-off Control Circuit Connections
Wiring Plug Header
Wiring Plug Headers with Motion-allowed Jumper
Kinetix 6000 or Kinetix 7000 Drives (Kinetix 6000 drive is shown)

In this example, system 1 contains two (single-wide) Kinetix 6000 drives using the safe-off feature wired with two (double-wide) Kinetix 6000 drives in system 2. The wiring headers with motion-allowed jumpers have been replaced as shown. The third axis in system 1 does not use the safe-off feature, so the wiring header and motion-allowed jumper remain installed.

Typical Kinetix 6000 Safe-off Configuration

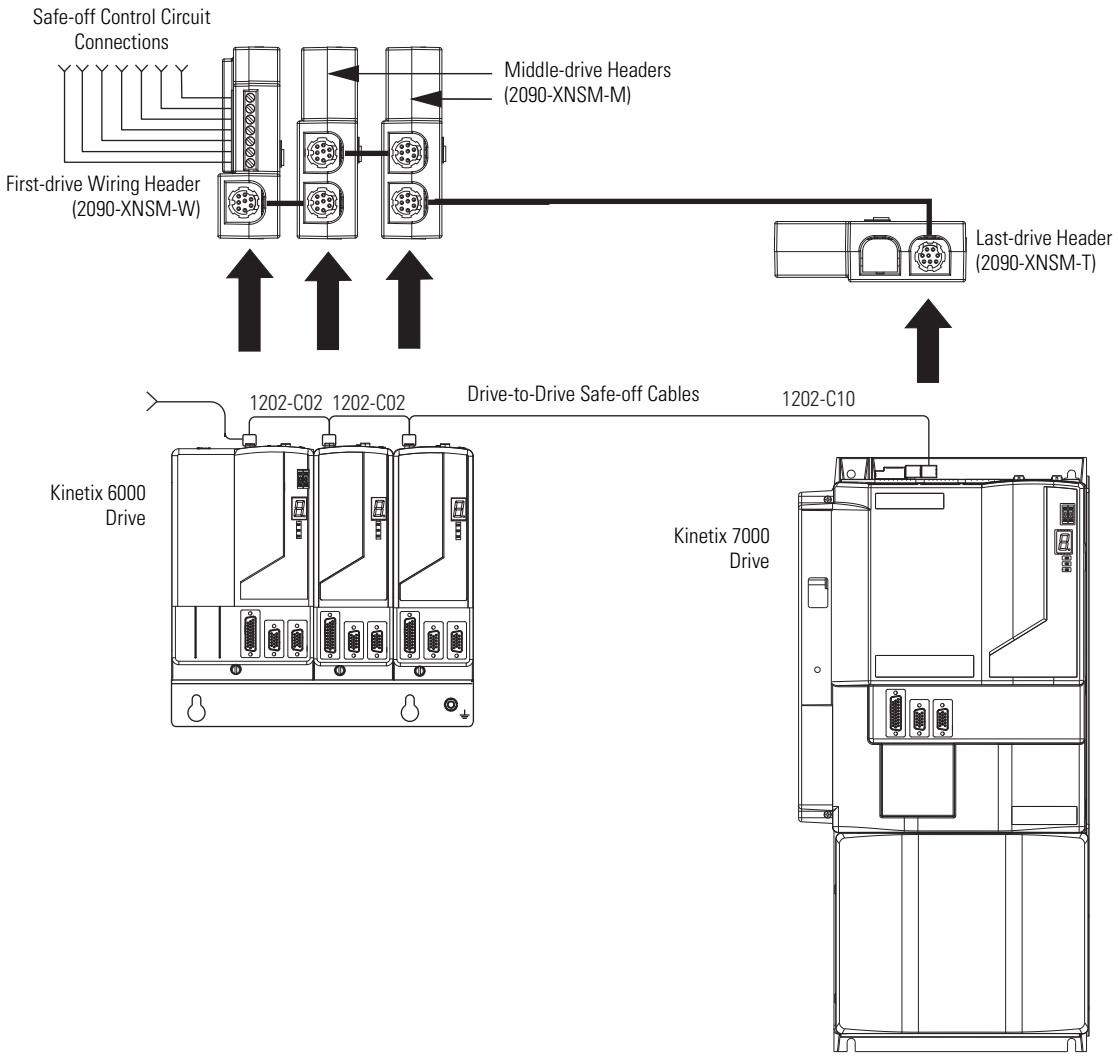


IMPORTANT Due to the current capacity limitation of the safe-off cable connectors, multiple safe-off drive configurations must not exceed eight Kinetix 6000 or Kinetix 7000 drive modules.

Cable connections to middle-drive headers (catalog number 2090-XNSM-M) can be made to either connector. Input and output is not specified.

In this example, the Kinetix 6000 power rail contains three (single-wide) drives using the safe-off feature and wired with one Kinetix 7000 drive. The wiring headers and motion-allowed jumpers have been replaced as shown.

Typical Kinetix 6000 to Kinetix 7000 Safe-off Configuration



IMPORTANT Due to the current capacity limitation of the safe-off cable connectors, multiple safe-off drive configurations must not exceed eight Kinetix 6000 or Kinetix 7000 drive modules.

Cable connections to middle-drive headers (catalog number 2090-XNSM-M) can be made to either connector. Input and output is not specified.

Safe-off Wiring Examples for SIL 3 Applications

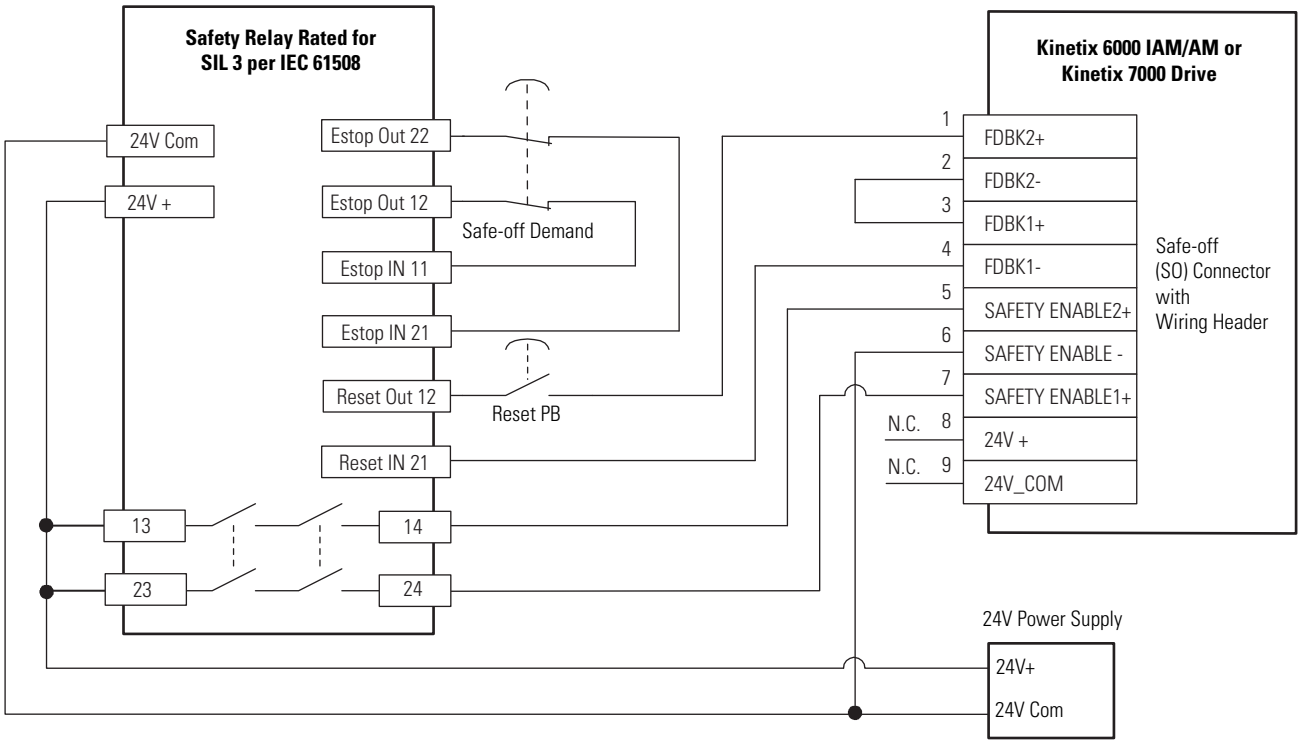
The following illustrations show typical wiring diagrams for the Kinetix 6000 and Kinetix 7000 safe-off drives:

- Typical single drive (stop category 0) configuration
- Typical single drive (stop category 1) configuration

ATTENTION

Category 1 (controlled stop) must be used and zero speed verified, prior to engaging the motor holding (parking) brake. Disabling the output by any means and engaging the holding brake with the motor in motion will result in premature failure of the brake.

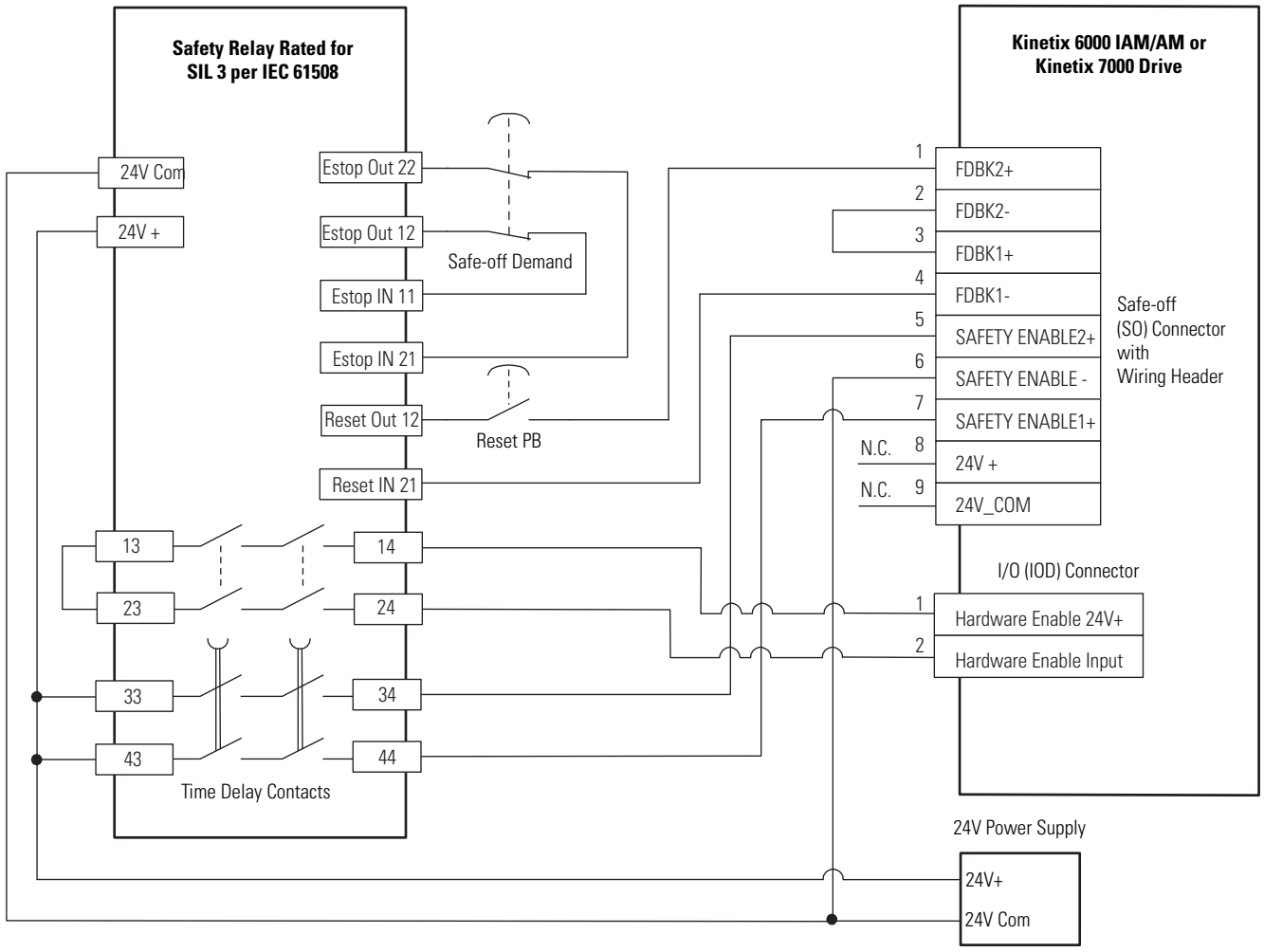
Single Drive (Stop Category 0) with Safety Relay Configuration



IMPORTANT

Pins SO-8 (internal 24V+ supply) and SO-9 (24V_COM) are used only by the motion-allowed jumper to defeat the safe-off function. When the safe-off function is in operation, the 24V supply must come from an external source.

Single Drive (Stop Category 1) with Safety Relay Configuration

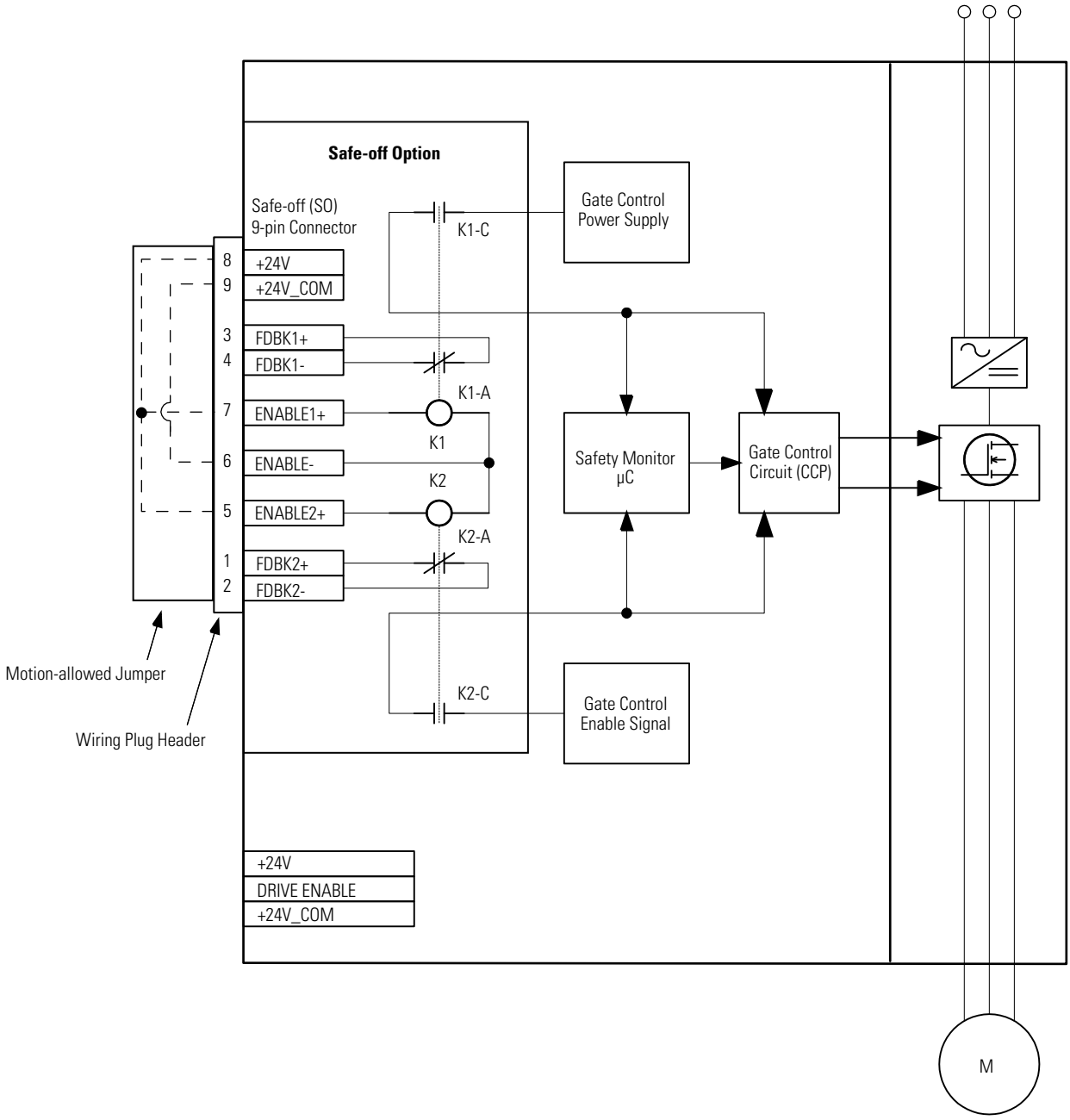


IMPORTANT Pins SO-8 (internal 24V+ supply) and SO-9 (24V_COM) are used only by the motion-allowed jumper to defeat the safe-off function. When the safe-off function is in operation, the 24V supply must come from an external source.

Safe-off Block Diagram

The safe-off block diagram is shown below with the wiring header and motion-allowed jumper installed. This is the default configuration. With the motion-allowed jumper installed, the safe-off feature is not used.

Safe-off Function Block Diagram



Safe-off Wiring Requirements

These are the safe-off (SO) wiring requirements. Wire should be copper with 75 °C (167 °F) minimum rating.

IMPORTANT The National Electrical Code and local electrical codes take precedence over the values and methods provided.

IMPORTANT Stranded wires must terminate with ferrules to prevent short circuits, per table D7 of EN 13849.

Safe-off (SO) Connector		Recommended Wire Size		Strip Length mm (in.)	Torque Value N•m (lb•in)
Pin	**Signal**	**Stranded Wire with Ferrule** mm^2 (AWG)	**Solid Wire** mm^2 (AWG)		
SO-1 SO-2 SO-3 SO-4 SO-5 SO-6 SO-7 SO-8 SO-9	FDBK2+ FDBK2- FDBK1+ FDBK1- SAFETY ENABLE2+ SAFETY ENABLE- SAFETY ENABLE1+ 24V + 24V_COM	0.75 (18)	1.5 (16)	7.0 (0.275)	0.235 (2.0)

IMPORTANT Pins SO-8 (internal 24V+ supply) and SO-9 (24V_COM) are used only by the motion-allowed jumper to defeat the safe-off function. When the safe-off function is in operation, the 24V supply must come from an external source.

IMPORTANT To be sure of system performance, run wires and cables in the wireways as established in the user manual for your drive.

Refer to Additional Resources on page 6 for the appropriate publication.

Refer to Appendix B beginning on page 37 for Kinetix 6000 interconnect diagrams with other Allen-Bradley safety products.

Specifications

This chapter provides safe-off feature specifications for your Kinetix 6000 and Kinetix 7000 drives.

Topic	Page
Safe-off Response Time Specifications	35
Safe-off Signal Specifications	36

Safe-off Response Time Specifications

The system reaction time is the amount of time from a safety-related event as input to the system until the system is in the safe state. Faults within the system can also have an effect upon the reaction time of the system. The safe-off response time for the Kinetix 6000 and Kinetix 7000 safe-off drives is 25 ms. This is the time from change of state at the drive input to change of state at the drive output.

ATTENTION

The safe-off response time is typical of drive performance. Actual system response time will vary depending on your application.

Safe-off Signal Specifications

The following tables provide specifications for the safe-off signals used in the Kinetix 6000 and Kinetix 7000 safe-off drives.

Safe-off ENABLE Signal Specifications

Relay coil specifications for the ENABLE signals are described in this table.

Parameter	Nom	Min	Max
Pull-in Voltage	24V	18V	26.4V
Drop-out Voltage	—	0V	2.4V
Coil Resistance	720 Ω	648 Ω	792 Ω
Coil Current	33.3 mA	—	55.0 mA
Pull-in Time	25 ms	—	—
Drop-out Time	20 ms	—	—

Safe-off FDBK Signal Specifications

Relay contact specifications for the FDBK signals are described in the table below.

Parameter	Value
Contact Resistance (1 A, 24V dc)	≤100 mΩ
Contact Resistance (10 mA, 5V dc)	≤20 Ω
Contact Load (min)	10 mA, 5V dc
Rated Current	8 A
Rated Voltage	240V ac
Breaking Capacity, ac (max)	2000VA

Kinetix Safe-off Wiring Diagrams

This appendix provides typical wiring diagrams for the Kinetix 6000 and Kinetix 7000 safe-off drives with other Allen-Bradley safety products.

Topic	Page
Kinetix Safe-off/Safety Relay Configurations	38
Kinetix Safe-off/GuardLogix Configurations	42
Kinetix Safe-off/GuardPLC Configurations	46

For additional information regarding Allen-Bradley safety products, including safety relays, light curtain, and gate interlock applications, refer to the Safety Products Catalog, website http://ab.com/catalogs.

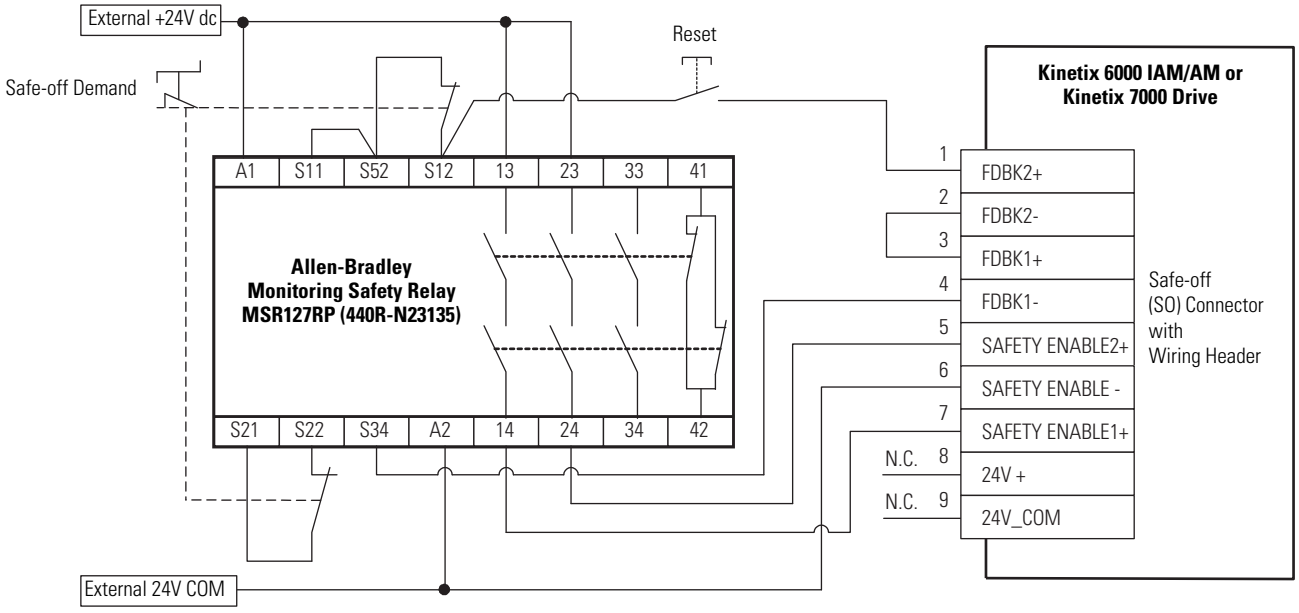
ATTENTION

Category 1 (controlled stop) must be used and zero speed verified, prior to engaging the motor holding (parking) brake. Disabling the output by any means and engaging the holding brake with the motor in motion will result in premature failure of the brake.

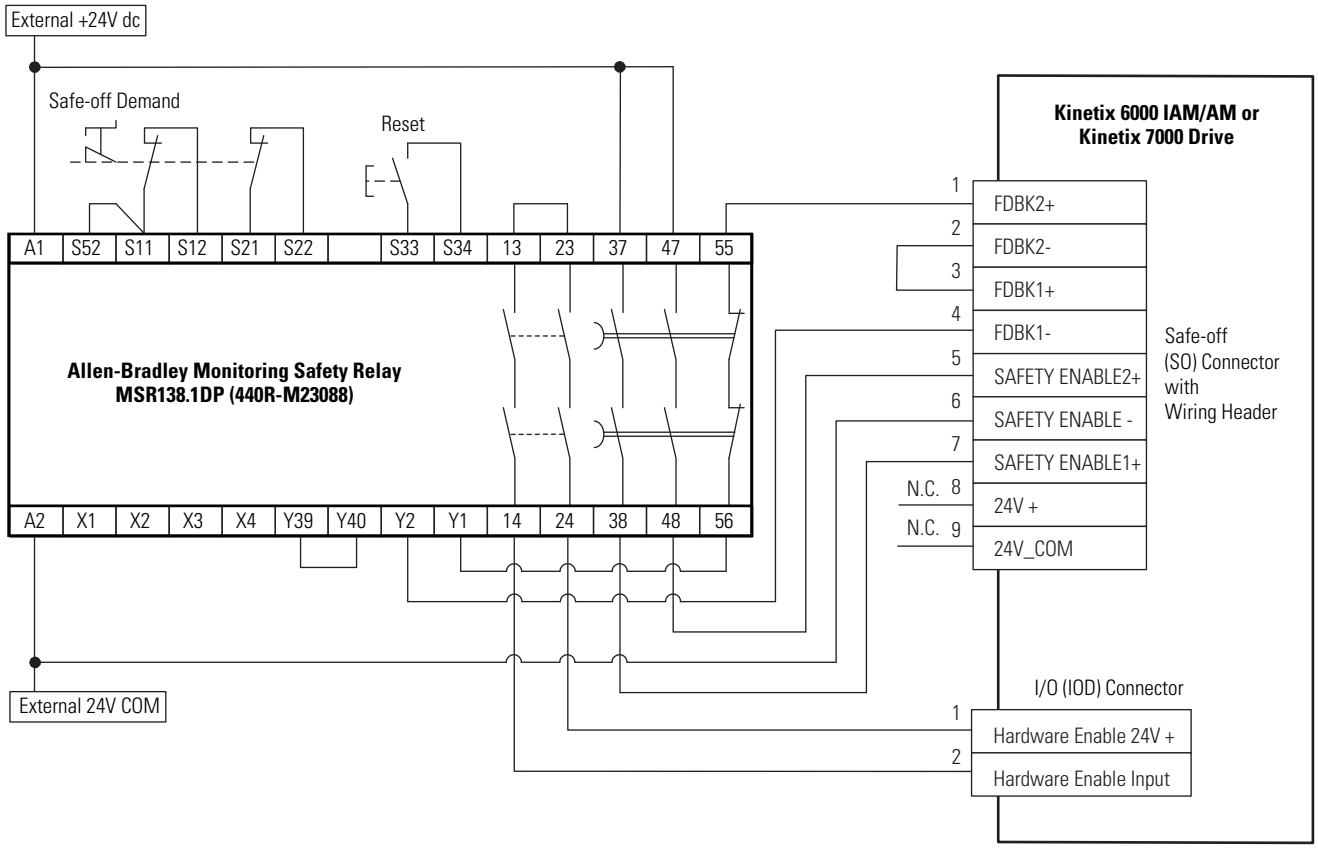
Kinetix Safe-off/Safety Relay Configurations

In the diagrams beginning below, the Kinetix 6000 and Kinetix 7000 drive safe-off connector is shown wired to an Allen-Bradley safety relay.

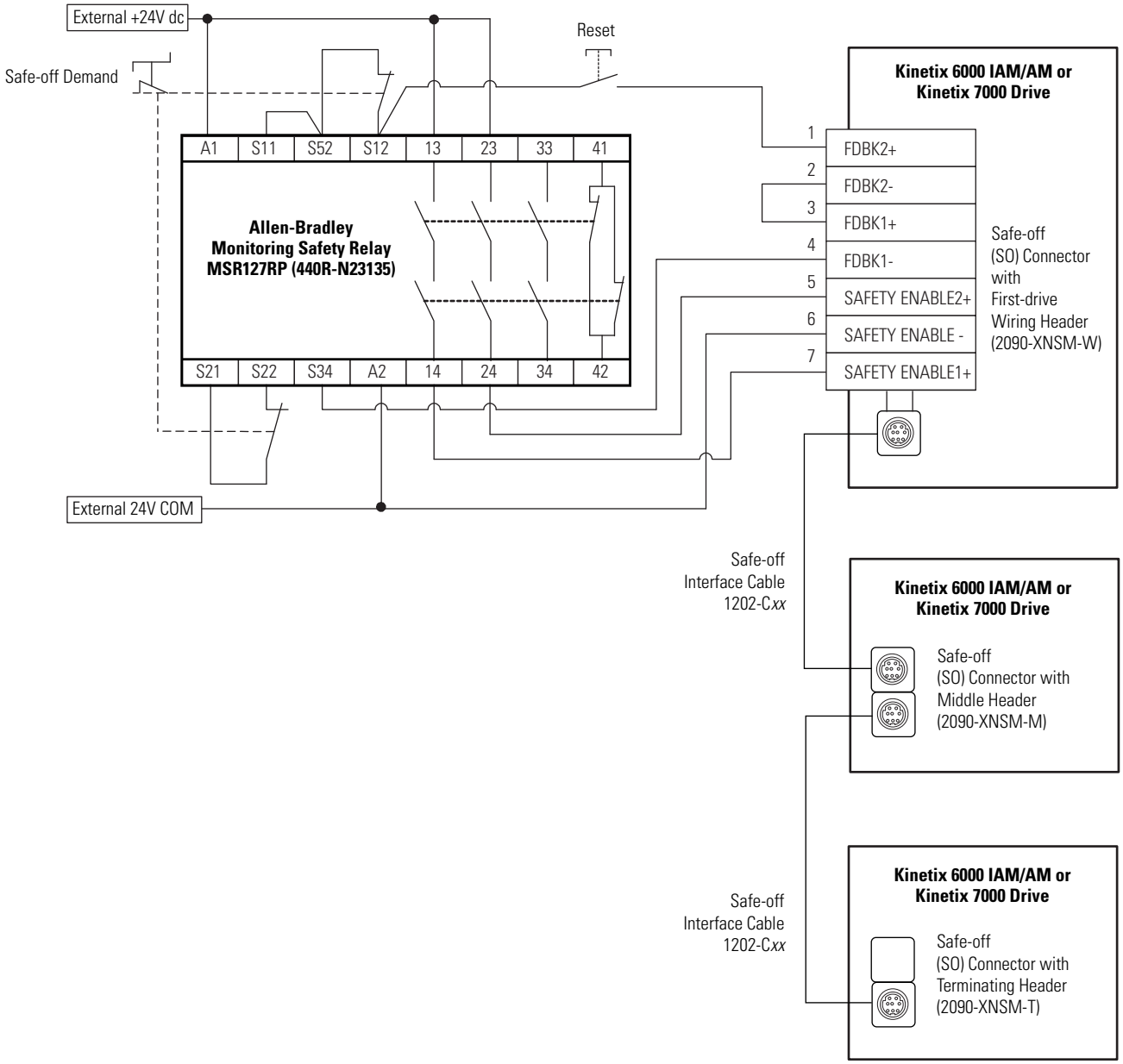
Single-axis Relay Configuration (Stop Category 0)



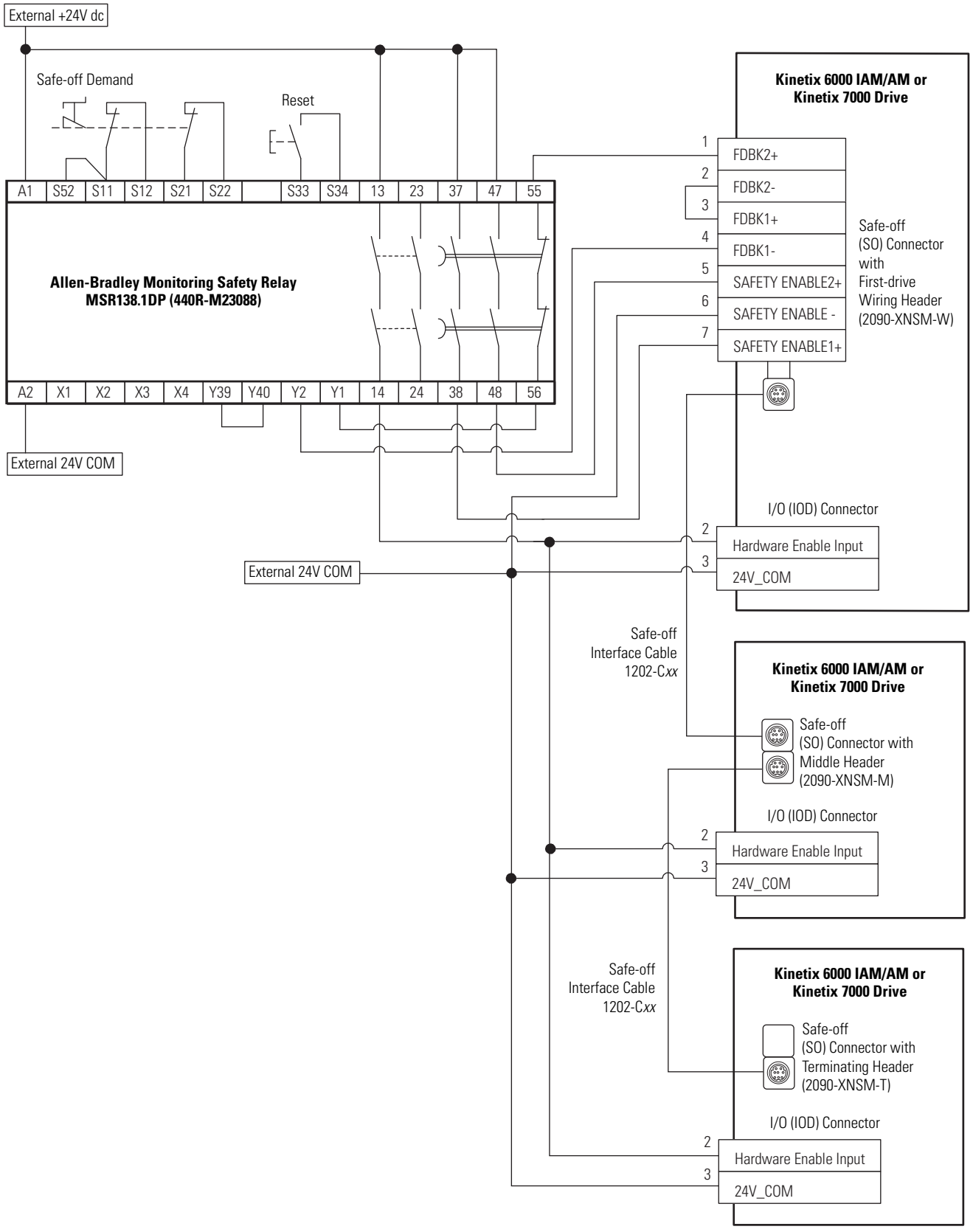
Single-axis Relay Configuration (Stop Category 1)



Multi-axis Relay Configuration (Stop Category 0)



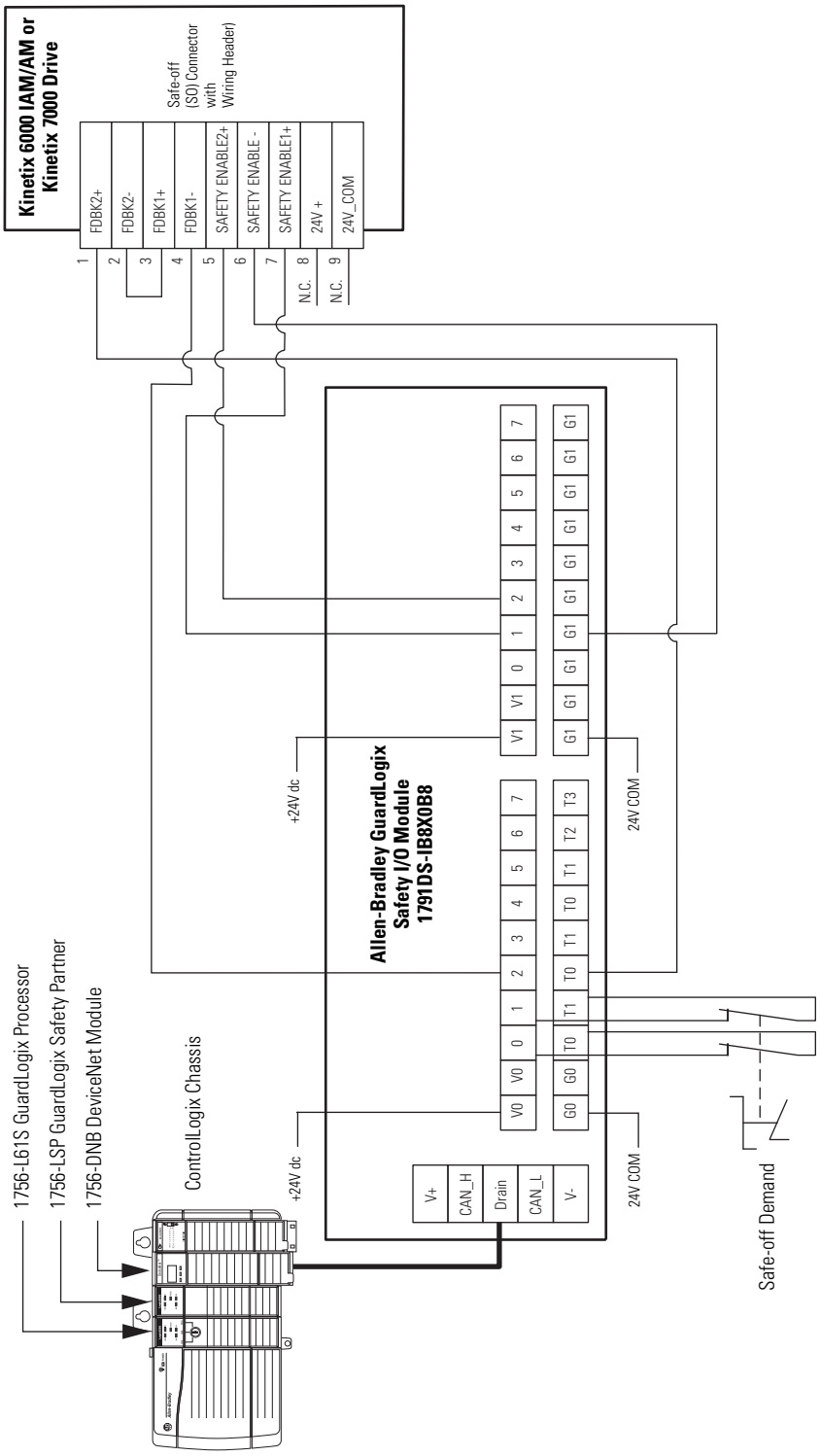
Multi-axis Relay Configuration (Stop Category 1)



Kinetix Safe-off/GuardLogix Configurations

In these diagrams, the Kinetix 6000 and Kinetix 7000 drive safe-off connector is shown wired to an Allen-Bradley GuardLogix controller.

Single-axis GuardLogix Configuration (Stop Category 0)

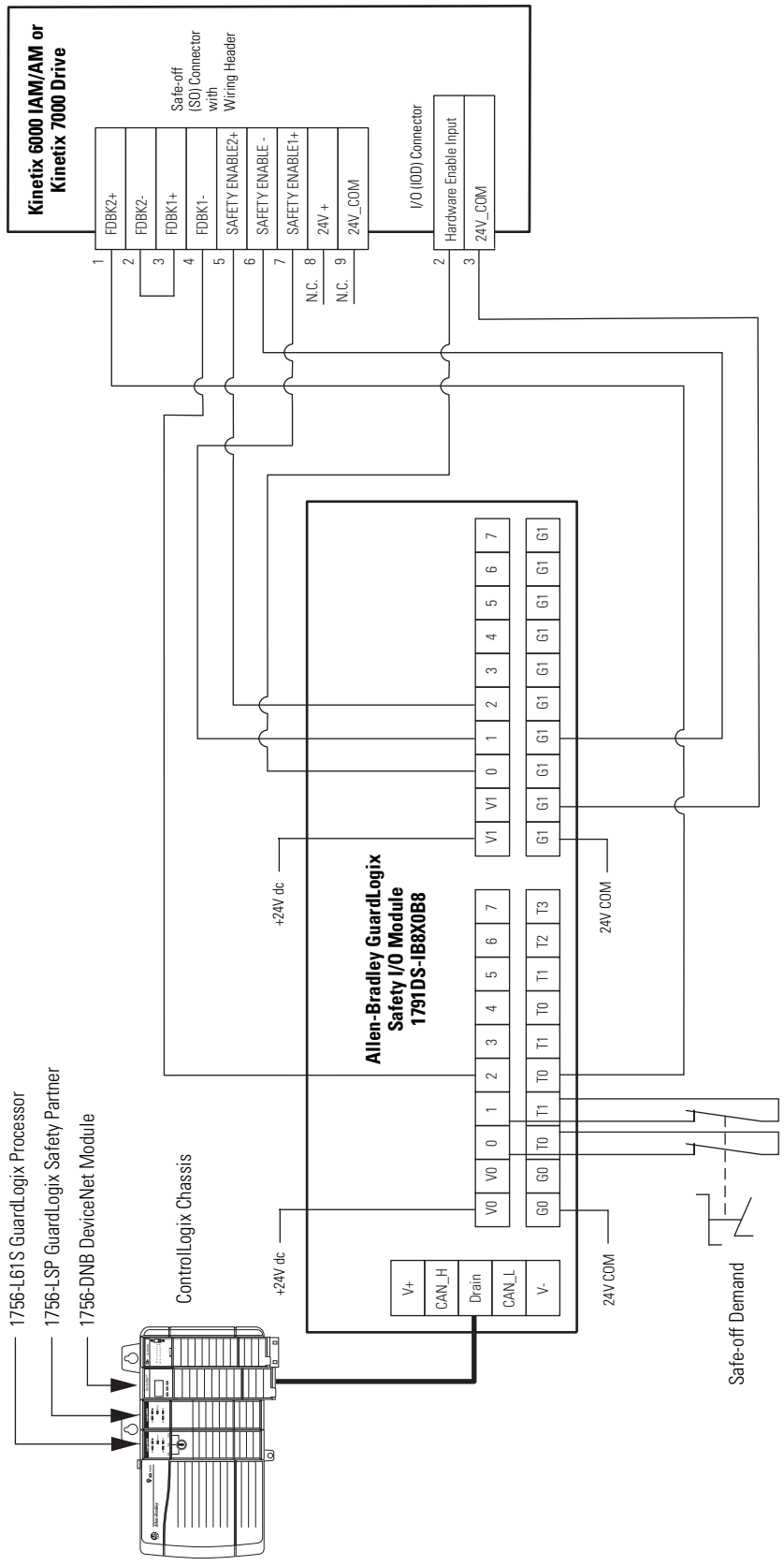


IMPORTANT

Proper logic and commissioning of the safety controller must be configured.

Refer to the DeviceNet Modules in Logix5000 Control Systems User Manual, publication DNET-UM004, and the DeviceNet Safety User Manual, publication 1791DS-UM001, for more information.

Single-axis GuardLogix Configuration (Stop Category 1)

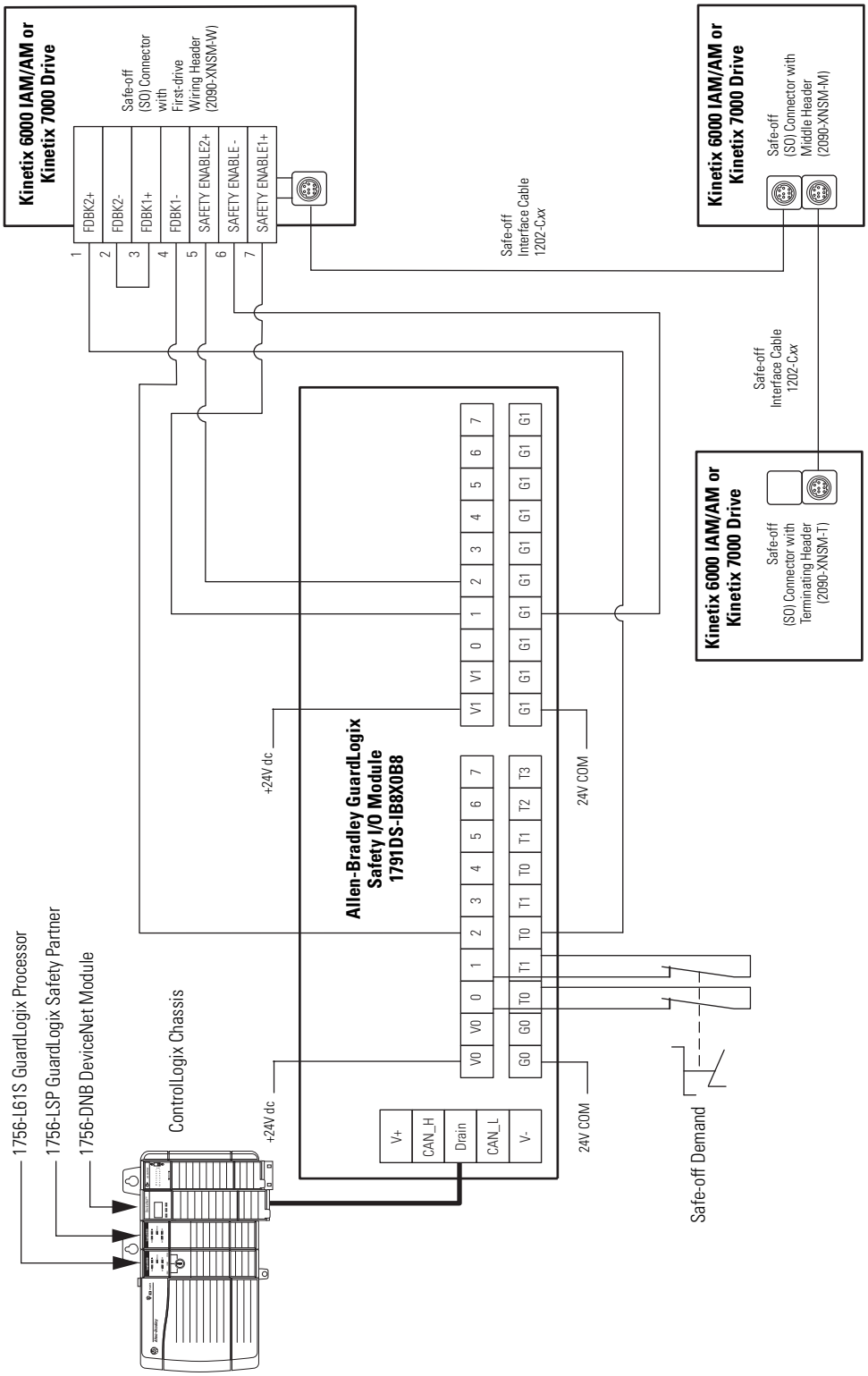


IMPORTANT

Proper logic and commissioning of the safety controller must be configured.

Refer to the DeviceNet Modules in Logix5000 Control Systems User Manual, publication DNET-UM004, and the DeviceNet Safety User Manual, publication 1791DS-UM001, for more information.

Multi-axis GuardLogix Configuration (Stop Category 0)

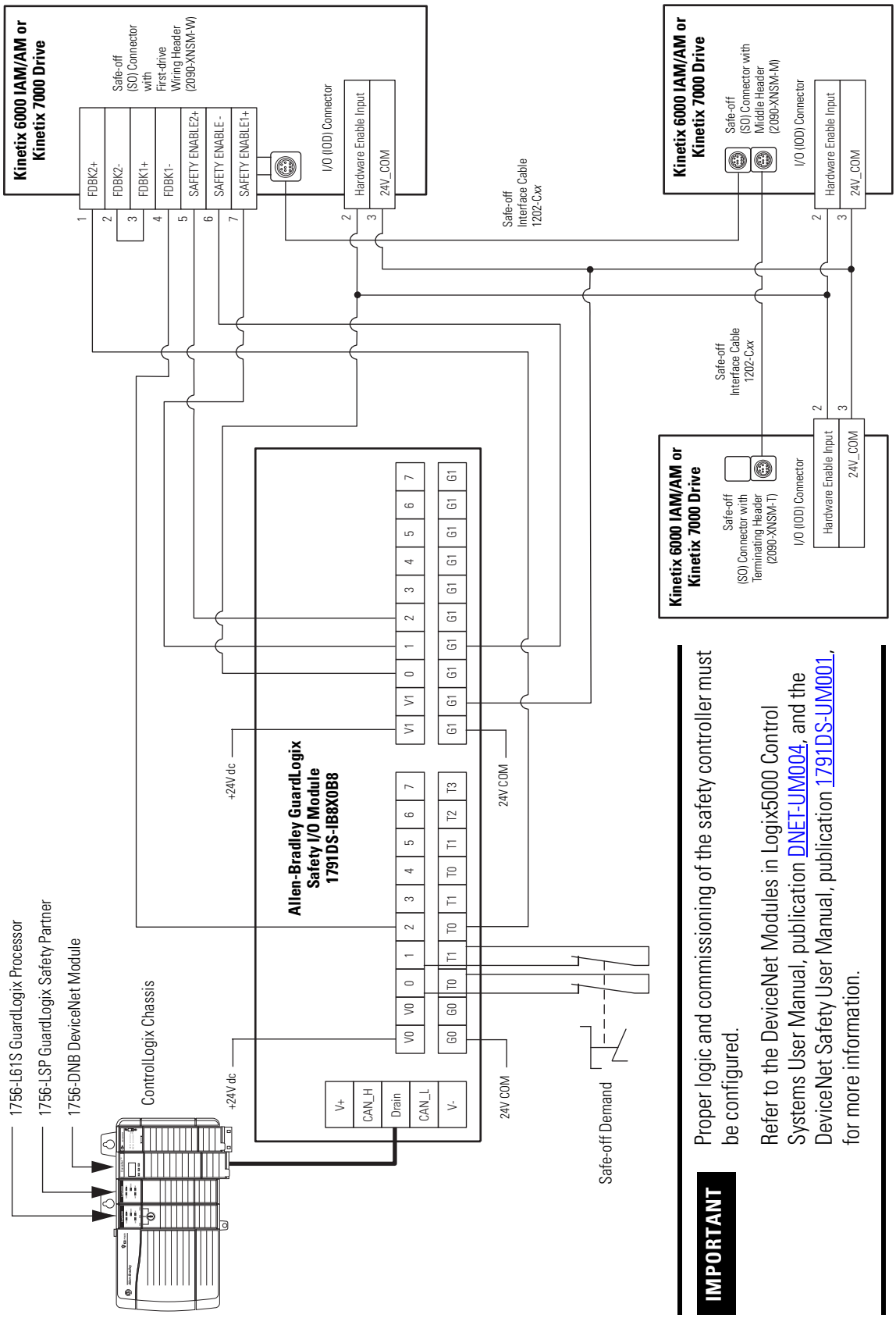


IMPORTANT

Proper logic and commissioning of the safety controller must be configured.

Refer to the DeviceNet Modules in Logix5000 Control Systems User Manual, publication DNET-UM004, and the DeviceNet Safety User Manual, publication 1791DS-UM001, for more information.

Multi-axis GuardLogix Configuration (Stop Category 1)



IMPORTANT

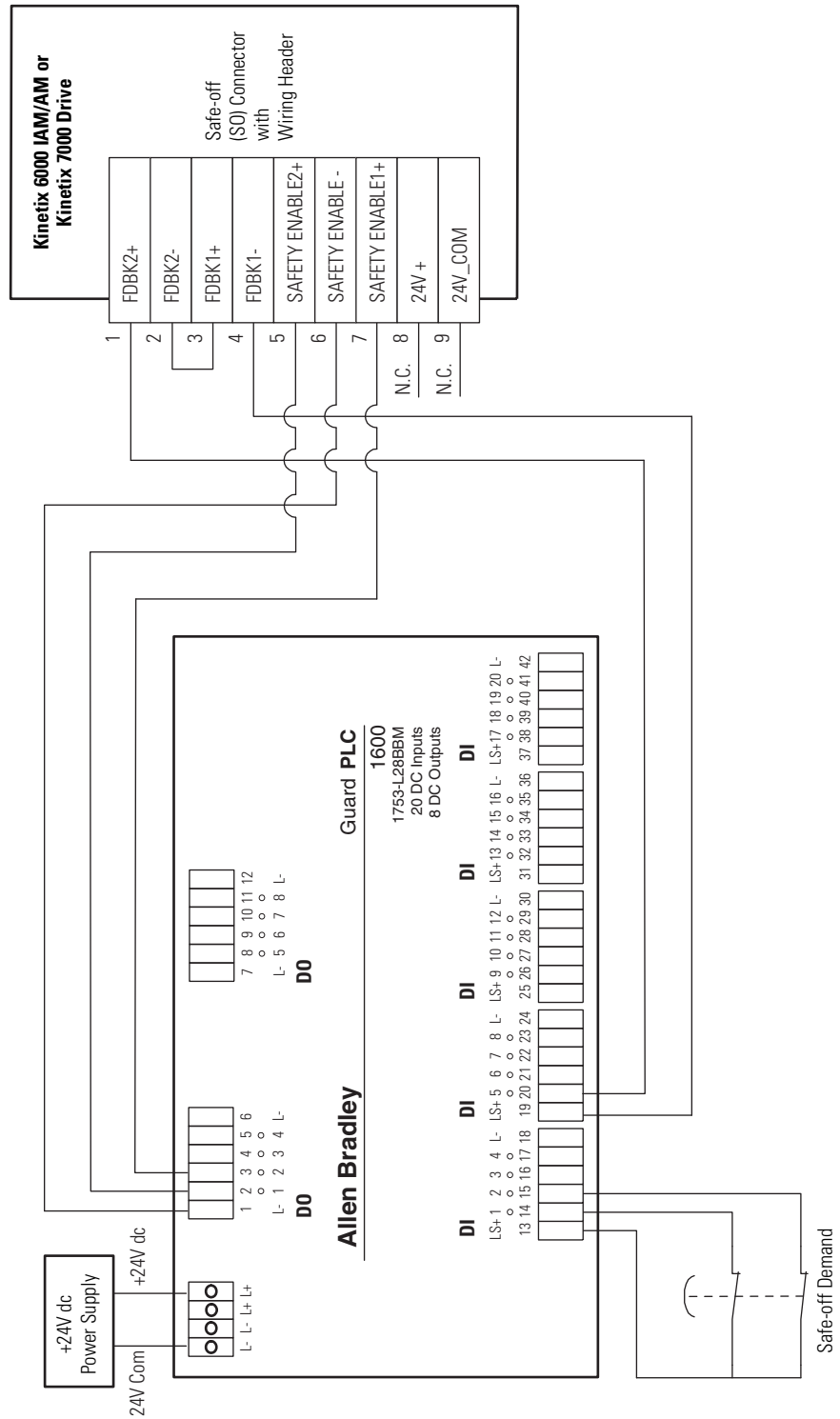
Proper logic and commissioning of the safety controller must be configured.

Refer to the DeviceNet Modules in Logix5000 Control Systems User Manual, publication DNET-UM004, and the DeviceNet Safety User Manual, publication 1791DS-UM001, for more information.

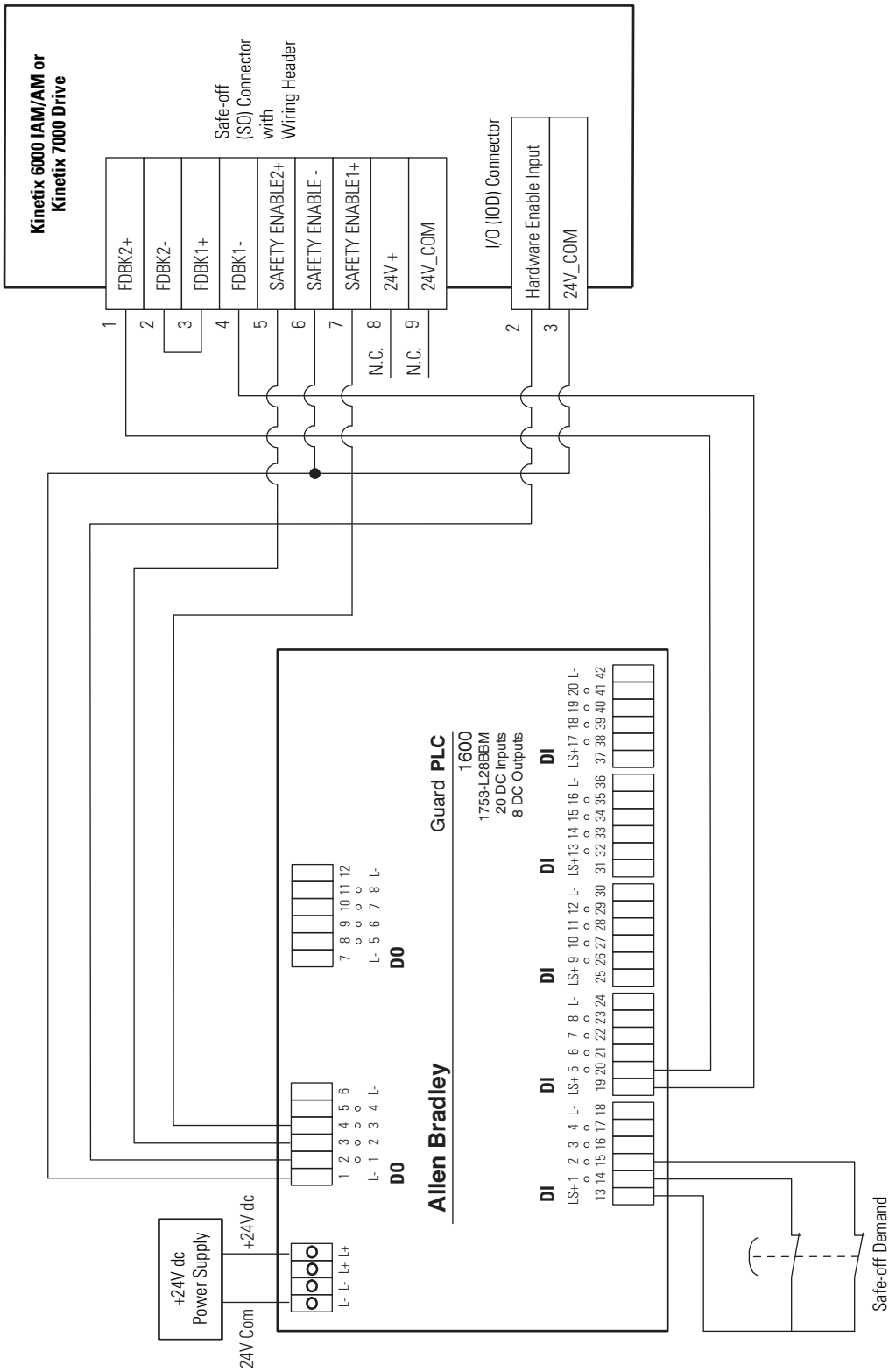
Kinetix Safe-off/GuardPLC Configurations

In these diagrams, the Kinetix 6000 and Kinetix 7000 drive safe-off connector is shown wired to an Allen-Bradley GuardPLC controller.

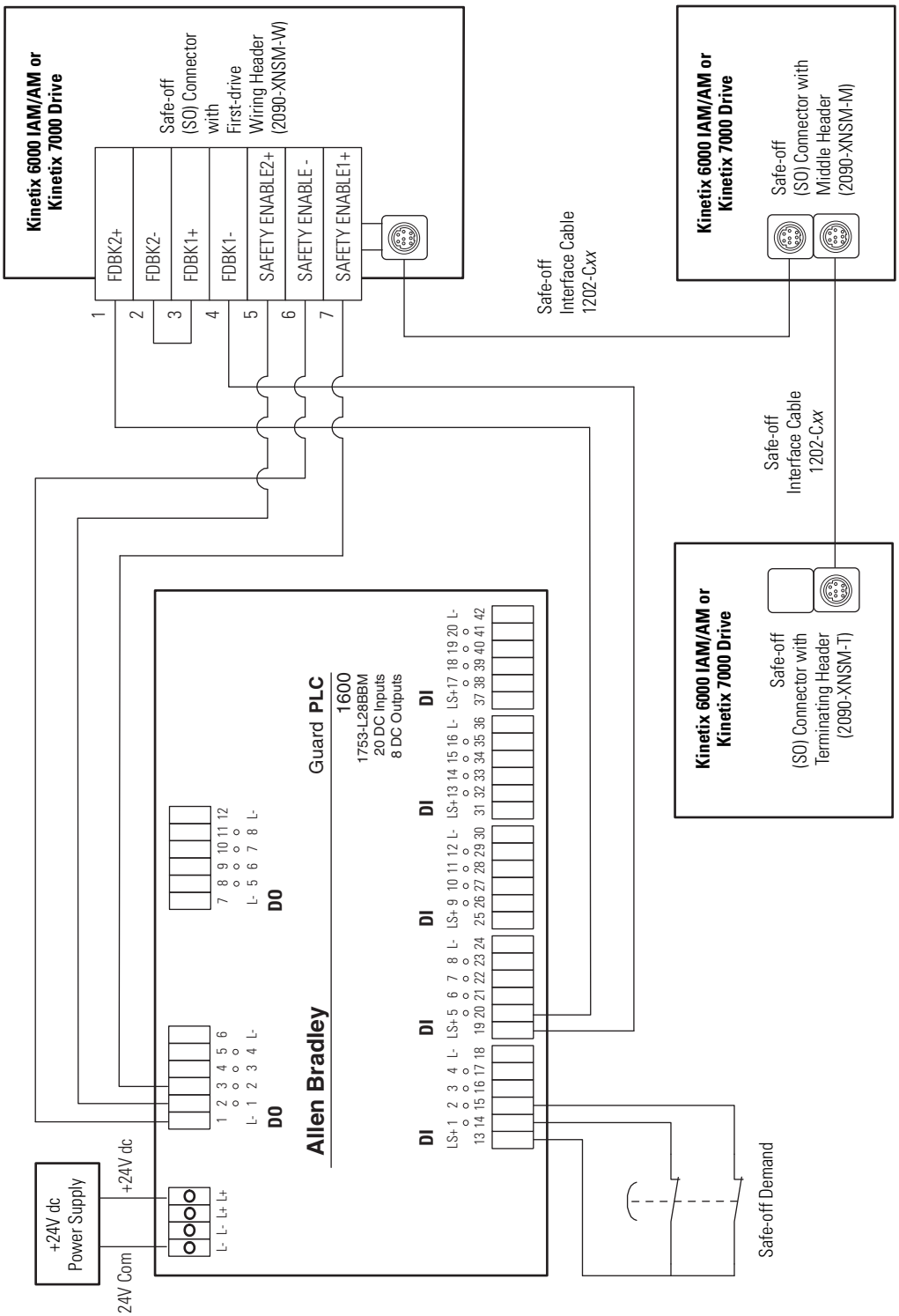
Single-axis GuardPLC Configuration (Stop Category 0)



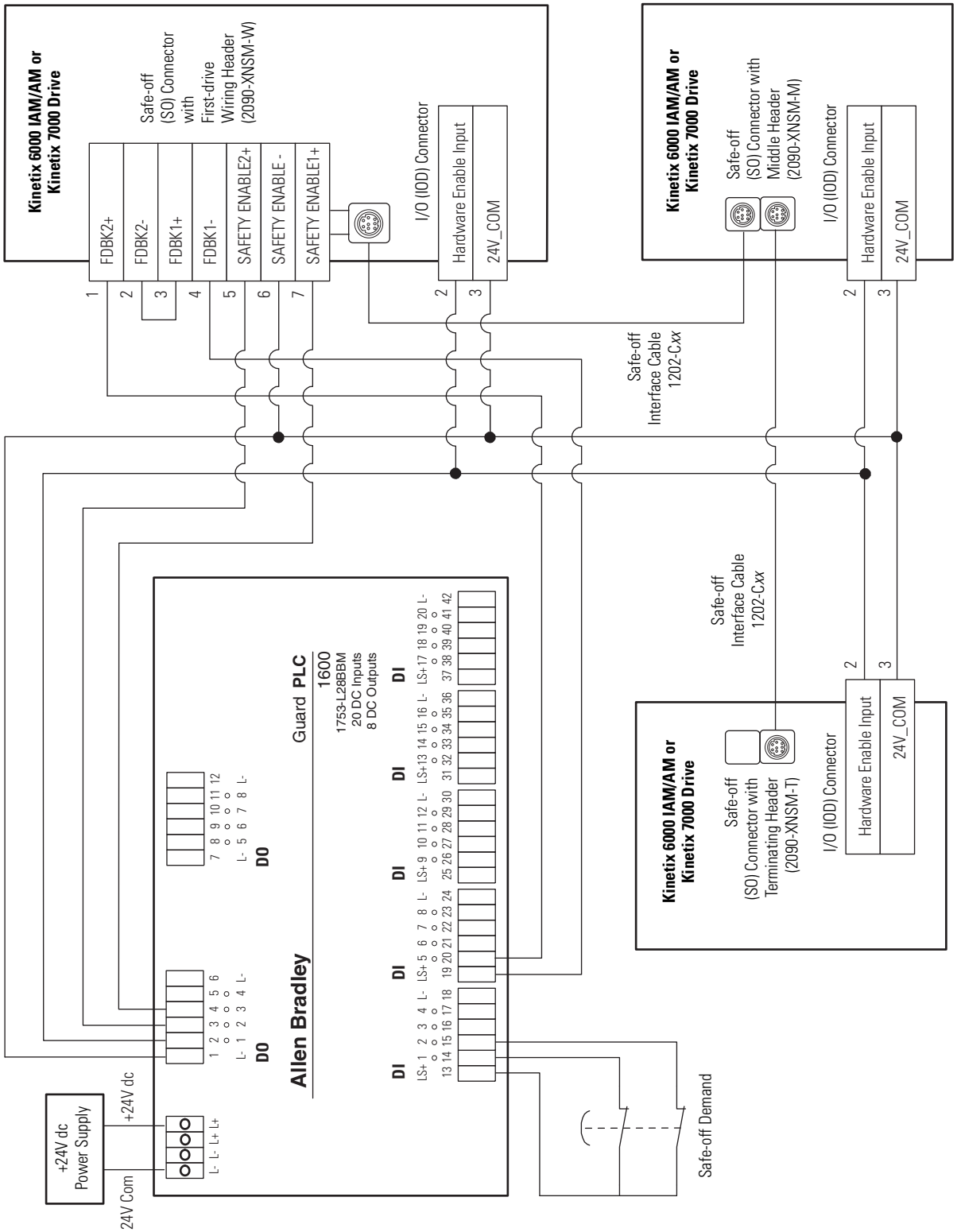
Single-axis GuardPLC Configuration (Stop Category 1)



Multi-axis GuardPLC Configuration (Stop Category 0)



Multi-axis GuardPLC Configuration (Stop Category 1)



Numerics

1oo2 5, 14

A

about this publication 5

B

block diagram 32

C

cables
  drive-to-drive 23, 28, 29
catalog, safety products 37
category 3
  requirements 8
  stop category definitions 8
CE
  CE conformity 26
  complying with CE 25
  meeting requirements 26
connector location 19
connector pinout 18
conventions 5

D

drive components 13
drive-to-drive cables 28, 29

E

EMC directive 25
EN 954-1 CAT 3 7
  requirements 8
  stop category definitions 8
enable signal specifications 36

F

failure 15
feedback signal specifications 36
first-drive wiring header 21

G

GuardLogix examples 42
GuardPLC examples 46

H

hardware fault tolerance 14
headers 20
  first-drive wiring 21
  last-drive 22
  middle-drive 22
  motion allowed jumper 20
  wiring plug 21
HFT 5, 14

I

IEC 61508
  SIL 3 certification 7

L

last-drive header 22
low voltage directive 26

M

middle-drive header 22
motion allowed jumper 20

O

one out of two (1oo2) 5, 14
operation 9
  understanding 26

P

PFD 5
  calculation 14
  definition 14
  example 15
PFH 5
  calculation 14
  definition 14
  example 15
proof tests 10

R

related documentation 6
response time 11
  specifications 35

S

safe failure fraction 14
safe-off
  condition 11
  drive fault 11
  mismatch 10

safe-off feature
  block diagram 32
  connector location 19
  connector pinout 18
  drive components 13
  GuardLogix examples 42
  GuardPLC examples 46
  headers 20
  interface cables 23
  operation 9
  proof tests 10
  safety relay examples 38
  SO connector 17
  understanding operation 26
  when failure occurs 15
  wiring example, stop cat. 0 30
  wiring example, stop cat. 1 31
  wiring requirements 33
safety products catalog 37
safety relay examples 38
SFF 5, 14
SIL 3 certification
  TÜV Rheinland 7
  user responsibilities 8
SO connector 17
specifications
  safe-off enable signals 36
  safe-off feedback signals 36
  safe-off response time 35

T

terminology 5
training 5
troubleshooting
  error code E49 10
  flowchart 12
  safe-off condition 11
  safe-off drive fault 11
  table 10

W

who should use this manual 5
wiring
  GuardLogix examples 42
  GuardPLC examples 46
  safety relay examples 38
  stop cat. 0 example 30
  stop cat. 1 example 31
wiring plug header 21
wiring requirements 33

Notes:

Notes:

Rockwell Automation Support

Rockwell Automation provides technical information on the Web to assist you in using its products. At http://support.rockwellautomation.com, you can find technical manuals, a knowledge base of FAQs, technical and application notes, sample code and links to software service packs, and a MySupport feature that you can customize to make the best use of these tools.

For an additional level of technical phone support for installation, configuration, and troubleshooting, we offer TechConnect Support programs. For more information, contact your local distributor or Rockwell Automation representative, or visit http://support.rockwellautomation.com.

Installation Assistance

If you experience a problem with a hardware module within the first 24 hours of installation, please review the information that's contained in this manual. You can also contact a special Customer Support number for initial help in getting your module up and running.

United States	1.440.646.3434 Monday – Friday, 8am – 5pm EST
Outside United States	Please contact your local Rockwell Automation representative for any technical support issues.

New Product Satisfaction Return

Rockwell tests all of its products to ensure that they are fully operational when shipped from the manufacturing facility. However, if your product is not functioning, it may need to be returned.

United States	Contact your distributor. You must provide a Customer Support case number (see phone number above to obtain one) to your distributor in order to complete the return process.
Outside United States	Please contact your local Rockwell Automation representative for return procedure.

www.rockwellautomation.com

Power, Control and Information Solutions Headquarters

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